A Changing Fundy Environment: Emerging Issues, Challenges and Priorities

Proceedings of the 12th BoFEP Bay of Fundy Science Workshop,
Truro, Nova Scotia, 9–12 May 2018

Editors

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Preface

This publication describes the program, plenary and public talks, papers, posters, panel presentations, and discussions at the 12th BoFEP Bay of Fundy Science Workshop, held on the Agricultural Campus, Dalhousie University, Truro, Nova Scotia, 9–12 May 2018. The BoFEP workshops have been held since 1996, mostly every other year, the objective being to offer a forum for information exchange on recent Fundy research and monitoring, and community oriented projects, and for discussion about ongoing and emerging environmental and resource issues in the Bay of Fundy, the greater Gulf of Maine, and the surrounding watersheds. Proceedings of previous workshops are on the web, at www.bofep.org/workshops.

The 12th workshop was attended by approximately 115 people, mostly from Nova Scotia and New Brunswick. It was very encouraging to see so many young people in various positions attend and engage in the discussions. BoFEP was delighted to award Rachel Cadman and Jaya Fahey with the Best Student Poster and Paper presentation respectively. The plenary and public talks were on the North Atlantic Right whale, marine debris and the Bay of Fundy's future. Paper sessions covered tidal energy, fisheries ecology and management, monitoring and contaminants, integrated coastal management, dykelands and tidal restoration, the new oceans protection plan, and marine protected areas. Three panels were held – ocean literacy and awareness, information use at the science-policy interface, and future research needs and BoFEP's continued role as an NGO. An excellent field trip took place, with tidal bore rafting on the nearby Shubenacadie River estuary.

The program reflected some of the focus areas of the past 20 years of BoFEP's activities. Earlier on, BoFEP sponsored and supported research on wetlands and dykes. More recently, it sponsored research on chemical contaminants in the Bay. BoFEP also contributed to an analysis of data from a long-term oceanographic monitoring station in Passamaquoddy Bay. As well, we undertook projects to help communities identify issues of concern and ways to respond to climate change. Most recently, we conducted a project on "Living Shorelines" with components of research, a Talking Circle on middens and their significance, and information for coastal landowners on coastal erosion. Importantly, we have continued these biennial workshops to facilitate communication of new research findings and new opportunities for collaborative work across the disciplines.

It is sincerely hoped that the reader will find this publication of interest and value and will consider participating in future workshops and activities of BoFEP. In this era of climate change, greater demand for living and non-living marine resources, and many threats to marine wildlife and biodiversity, the Bay of Fundy needs proactive research and monitoring to ensure that effective conservation and protection measures are in place. The information exchange at such workshops is vital to this task – linking the science to policy and decision-making in the many activities of coastal management, hence ensuring a bright future for this globally unique, macro-tidal coastal ecosystem.

Acknowledgements

A special thank you to Fisheries and Oceans Canada, the Fundy Ocean Research Center for Energy, and Mountain Equipment Coop for their support

Fisheries and Oceans Canada
Pêches et Océans Canada

FORCE
Fundy Ocean Research Center for Energy

MEC

Workshop Organizing Committee

Joshua McNeely and Marianne Janowicz, Co-Chairs
Sarah Chamberlain (Logistics)
Blythe Chang (Program)
Jon Percy (Logistics)
Susan Rolston (Logistics)
Peter Wells (Program)

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The core supporters, financial and/or in-kind, of BoFEP over the past 21 years have been the following:

- Environment Canada (now Environment and Climate Change Canada)
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- Fisheries and Oceans Canada
    - Bedford Institute of Oceanography
    - St. Andrews Biological Station
- Gulf of Maine Council on the Marine Environment, and its members
- Acadia University - Acadia Centre for Estuarine Research, Wolfville, NS
- Dalhousie University, Halifax, NS
- SeaPen Communications, Granville Ferry, NS

Many other groups (other universities, NGOs, private sector) have co-sponsored or supported in various ways the workshops and meetings of BoFEP over the years. All of the groups are greatly thanked for their long-term commitment and support.

As well, many individual members of BoFEP, in various capacities through their working positions or as volunteers, have given generously of their time, skills, and personal resources to BoFEP activities, projects and administration; their contributions have been critical to the functioning and program output of the organization.

Workshop Program

<table>
<tr><th></th><th>Wednesday
9 May</th><th colspan="3">Thursday
10 May</th><th colspan="3">Friday
11 May</th><th>Saturday
12 May</th></tr>
<tr><td>8:00</td><td rowspan="11"></td><td colspan="3">Registration</td><td colspan="3">Registration</td><td rowspan="5">Field Trip

Tidal Bore Rafting with Fundy Tidal Bore Adventures

Meet at 7:15 am for ride sharing departure</td></tr>
<tr><td>8:30</td><td colspan="3">Opening & Keynote Presentation
Dr. Kimberley T.A. Davies</td><td colspan="3">Keynote Presentation
Dr. Graham R. Daborn</td></tr>
<tr><td>10:00</td><td colspan="3">Break</td><td colspan="3">Break</td></tr>
<tr><td>10:30</td><td>Ocean Literacy and Awareness</td><td>Fisheries Ecology & Management 1</td><td>Integrated Coastal Management</td><td>Information Use at the Science-Policy Interface in Decision-making</td><td>Oceans protection Plan (OPP) 1</td><td>Dykelands & Tidal Restoration 3</td></tr>
<tr><td>12:00</td><td colspan="3">Lunch</td><td colspan="3">Lunch</td></tr>
<tr><td>1:30</td><td>Tidal Energy 1</td><td>Fisheries Ecology & Management 2</td><td>Dykelands & Tidal Restoration 1</td><td></td><td>OPP & Marine Protected Areas 2</td><td>Dykelands & Tidal Restoration 4</td><td rowspan="7"></td></tr>
<tr><td>3:00</td><td colspan="3">Break</td><td colspan="3">Break (2:30-2:45)</td></tr>
<tr><td>3:30</td><td rowspan="3">Tidal Energy 2</td><td rowspan="3">Monitoring & Contaminants</td><td rowspan="3">Dykelands & Tidal Restoration 2</td><td colspan="3" rowspan="2">Future Research in the Bay of Fundy and BoFEP’s Role Panel

Student Awards Presentation & Closing</td></tr>
<tr><td>4:00</td></tr>
<tr><td>5:00</td><td colspan="2" rowspan="2">Poster Session</td><td rowspan="2"></td><td colspan="3" rowspan="3"></td></tr>
<tr><td>5:30</td></tr>
<tr><td>6:00</td><td></td><td colspan="2"></td></tr>
<tr><td>7–9 pm</td><td>Opening Reception</td><td colspan="3">Keynote Public Presentation
Dr. Tony R. Walker
Start time 7:30 pm</td><td colspan="3"></td></tr>
</table>

In Memoriam

It was with great sadness that BoFEP learned of the passing of two of its longstanding New Brunswick members this past summer. Over the years, Peter Fenety and Owen Washburn served on both the Steering Committee and Management Committee of BoFEP. Their contributions to the organization, always positive, always enthusiastic and invariably insightful, were invaluable and will be sorely missed by all who shared their interest in and concern for the Bay of Fundy.

Peter Fenety
1947–2018

Owen Washburn
1937–2018

1. Keynote Addresses

An Uncertain Future: The Right Whales' Fight against Environment, Biology and Ocean Urbanization

Dr. Kimberley T.A. Davies, Department of Oceanography, Dalhousie University, Halifax, Nova Scotia (kim.davies@dal.ca)

Abstract

North Atlantic right whales (*Eubalaena glacialis*) are iconic Bay of Fundy animals that have become globally recognized as a poster child for the impacts of human activities on coastal environments. Their relatively unique life history makes them extremely susceptible to harm from certain human activities such as fishing gear entanglements and ship strikes, apparently more so that other large whales. Such harm then feeds back to impact the species' biology through a variety of lethal and sublethal effects. This talk examines the biological adaptations that put these animals at high risk, ranging from their feeding ecology to their reproductive cycles. This provides the context for discussing how changes in the Bay of Fundy environment and beyond have put the future of these animals in peril through impacting their population biology and risk from human activities. Looking to the future, unprecedented collaborative efforts are underway in Atlantic Canada that hope to improve the outlook for this species.

Further Reading

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Drowning in Debris: Solutions for a Global Pervasive Marine Pollution Problem

Dr. Tony R. Walker, School for Resource and Environmental Studies, Dalhousie University, Halifax, Nova Scotia (trwalker@dal.ca)

Extended Abstract

Oceans have become sinks for vast quantities of anthropogenic marine debris (Kershaw et al., 2011). Global marine debris has been a growing concern for decades and is one of the most widespread sources of pollution facing the world's oceans from the remote Arctic to the Antarctic (Walker et al., 1997; Bergmann et al., 2017; Waller et al., 2017). The most abundant and widespread source of marine debris is plastics, accounting for 60–95% of marine litter (Walker et al., 1997, 2006; Derraik, 2002). Jambeck et al. (2015) estimated 4.8–12.7 million metric tonnes (Mt) of mismanaged plastic waste entered the oceans in 2010. Over 300 million Mt are produced annually, but 50% are discarded after a single-use (Geyer et al., 2017). Single-use plastics (SUPs) includes plastic bags, microbeads, cutlery, straws, cups and polystyrene which are significant sources of marine pollution (Xanthos and Walker, 2017).

Plastic pollution in the oceans are comprised of microplastics (<5 mm diameter) a term first coined by Thompson et al. (2004) and macroplastics (>5 mm). Microplastics comprise: primary microplastics (microbeads), and secondary microplastics, from degraded macroplastics (plastic bags). Growing efforts have been made to monitor impacts of microplastics in the marine environment. Recent studies suggest that risks of microplastics (including degraded macroplastics, microbeads and microplastic fibres) in the marine environment may pose more of a threat than macroplastics (Rochman et al., 2015a). Marine plastic pollution has justifiably become an important global issue for citizens, governments, academics, and non-governmental organizations (NGOs) (Seltenrich, 2015). Economic and aesthetic impacts of marine plastic debris are estimated at USD $13 billion annually from lost tourism revenues from adverse impacts on recreational activities and navigation (Borrelle et al., 2017). Marine debris therefore poses a serious threat to our environment, economy, navigation and now recognized as a potential threat to human health. Yet marine debris is preventable.

In 2011, the Fifth International Marine Debris Conference (5IMDC), developed the *Honolulu Strategy*, an international framework to reduce marine plastic pollution (UNEP and NOAA, 2012; Pettipas et al., 2016; Walker, 2018a). Strategies from the *Honolulu Strategy* include market-based instruments (e.g., levies on plastic bags) for waste minimization or implementing policies, regulations, and legislation to reduce marine debris (e.g., imposing outright bans on various SUPs) (Xanthos and Walker, 2017). The *Honolulu Strategy* is a framework for a comprehensive and global effort to help reduce the ecological, human health, and economic impacts of marine debris. It was designed as a planning tool, common frame of reference for collaboration, and a monitoring tool for society, government, intergovernmental organizations, and the private sector.

Since that conference advances in government policies to curb the use of SUPs have helped increase public awareness of this pervasive issue (Rochman et al., 2015b; Xanthos and Walker, 2017). For example, UNEP (with support from 42 governments), declared a fight against plastics, announcing their global CleanSeas campaign in February 2017 to eliminate major sources of marine debris by 2022 (UNEP and NOAA, 2017). In January 2018, the European Commission (EC) adopted the first-ever Europe-wide strategy on plastics, transitioning towards a more circular economy (Liu et al., 2018). All plastic

packaging in the European Union (EU) must be reusable or recyclable by 2030, and use of SUPs including straws, cutlery and microplastics will be restricted. Following China's ban on importing recycled film plastics, interventions have intensified across developed countries (Walker, 2018b). Many countries and jurisdictions have already successfully implemented bans of SUP bags (Xanthos and Walker, 2017). Bans, partial bans, and fees have been implemented across local jurisdictions (e.g., North America), but national approaches have also been undertaken (e.g., across Europe). Some national bans on microbeads have been implemented. For example, the Canadian government classified microbeads as a toxin under the *Canadian Environmental Protection Act* and banned single-use toiletries and cosmetics containing microbeads from stores in July 2018 (Walker and Xanthos, 2018).

This presentation shared lessons learned and best practices to reduce and prevent marine debris and its impacts; promoting international co-learning; exchanging innovative ideas such as market incentives and communication strategies; and sharing latest research initiatives, methods, and results. For example, he Sixth IMDC which was held in San Diego, California in March 2018, brought together international marine debris researchers, natural resource managers, policy makers, industry representatives, and the nongovernmental community from around the world to participate to help transfer knowledge and expertise with more than 600 other marine debris stakeholders (https://internationalmarinedebrisconference.org/). Outcomes from this international marine debris conference included the pressing need to address and reduce the impacts of marine debris to vital natural resources, human health and safety, and the economy. To address this global marine debris problem, we need action and change-oriented solutions (UNEP and NOAA, 2017).

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The Bay of Fundy and its Future

Graham R. Daborn, Acadia Centre for Estuarine Research, Acadia University, Wolfville, Nova Scotia (graham.daborn@acadiau.ca)

Introduction

The Bay of Fundy is one of the most unusual coastal ecosystems known. In addition to having the world's highest recorded tides, the Bay exhibits high biological diversity, a wide diversity of habitats, and is biologically very productive. These assets have given rise to biological connections with a large part of the globe — the Arctic, North and South Atlantic, North, Central and South America, and Europe — through the migratory movements of numerous species of fish, birds and mammals.

However, it is evident that the Bay is also undergoing continuous change. The causes of this disequilibrium are both natural and anthropogenic: the dynamic responses of the Earth's crust to removal of the ice sheet after the last ice age, the continuous effects of shoreline and seafloor erosion and deposition, and shifting trophic relationships that are often poorly understood. Anthropogenic changes include the effects of natural resource harvesting, conversion of salt marshes, construction of dams, harbours, roads (etc.), eutrophication, and, of course, global climate change effects. If human activities are to be managed in order to preserve many of the attributes of the Bay, it is critical that we understand the effects of all of these changes and be able to forecast their future trends.

Figure 1. Map of the Bay of Fundy

Source: Brian Sanderson

What Do We Know?

Much of what we know about the Bay has resulted from proposals to convert some of the energy of the tides into electricity. Tidal power-related research has been under way for more than a century, conducted – especially in the last four decades – through collaboration of numerous scientists at many institutions, particularly local universities and government agencies.[1] This integrated, collaborative approach has enabled a level of understanding of the dynamic processes occurring in the Bay that has few parallels elsewhere. We understand, for example, that the great biodiversity of the Bay system – more than 2,300 species, including 120+ fish, 170+ marine birds, and more than 20 marine mammals, for example – reflects the notable diversity of habitats, which range from the deep, cold waters of the Outer Bay (cf. Figure 1) to the marshes and mudflats of the Upper Bay. These in turn result from the interaction of strong tides with the varied geology and hydrology of the whole watershed. High biodiversity is supported by different biophysical processes at each end of the Bay – both linked to the tides. In the Outer Bay, tidal movements force deep, cold and nutrient-rich water to the surface in extensive upwelling areas that provide rich foraging grounds for fish, birds and mammals. Tidal dynamics also enable large concentrations of plankton and small fish that attract marine mammals, and the rocky shore supports extensive growth of seaweeds and associated fauna. In contrast, in the Upper Bay primary productivity is provided by unusually productive saltmarshes and the microflora of extensive mudflats that attract millions of migratory birds and fish.

Although we think we know a good deal about the Bay, we are constantly challenged by new findings that often question the completeness of our understanding.

How Do We Know It?

Research started by the Fundy Environmental Studies Committee from 1977 to 1984 laid the groundwork for this comprehensive understanding through the development of numerical models of tides and trophic interactions,[2] whole-Bay sampling and monitoring programs, fish and shorebird tagging studies, and investigations of plankton, saltmarsh and mudflat dynamics. In many cases, these were the first studies conducted in the Upper Bay, and the first programs to try to link the ecosystems of the Bay together.[3] Not only was a huge amount of new information collected, and large numbers of young scientists provided with exceptional practical experience, but new research technologies were adopted or developed. There were the first essays into ecosystem modeling, the first studies of mudflat-based food webs, of sediment and saltmarsh biochemistry, the tagging of migratory fish, and analyses of shorebird feeding behaviour. The 1984 summary of knowledge[4] represented a major increase in our understanding. Subsequent reviews[5] show that, in spite of the decline of interest in tidal power in the 1980s, the research community of the region continued to work collaboratively to answer many unresolved issues, such as the vexing problem of fine sediment dynamics, and the presence and behaviour of fish, birds and mammals.

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[1] Through the International Passamaquoddy Fisheries Board (1931-1933;1956-1963 cf. IPFB 1959); the Fundy Environmental Studies Committee (FESC, 1977-1984); the Acadia Centre for Estuarine Research (ACER, 1984-present); and the Bay of Fundy Ecosystem Partnership (BoFEP, 1996-present).

[2] Keizer *et al.* 1987; Campbell and Wroblewsky 1986.

[3] Apart from shorebird studies, the absence of research into the Upper Bay can be attributed to the difficulty of working there, and to Huntsman's mistaken view that the water was unproductive because of its turbidity (cf. Huntsman 1952).

[4] Gordon and Dadswell 1984.

[5] For example, Percy *et al.* 1997; Jaques Whitford 2008.

Critical to many of these studies was the need to modify or develop new techniques for study. Modelling of fine sediments, for example, could not be based upon analyses of samples removed to a laboratory, but techniques for monitoring sediments *in situ* either did not exist, or were too imprecise. A whole new generation of field techniques, such as *Sea Carousel*,[6] *INSIST*, and Paterson's *Cohesive Strength Meter*,[7] were developed and tested. They proved far superior to laboratory flume studies when fine, cohesive sediments were involved. In addition, because physical, chemical and biological processes are all highly intertwined, efforts were made to monitor all dynamic phenomena simultaneously in the same place over many tidal cycles. The result was a tremendous increase in conceptual understanding of estuarine sediments. The LISP[8] project, which involved numerous scientists from Canada, the United Kingdom, the United States, France, Argentina and China, has been described as the 'time when intertidal sedimentology came of age'.

Similar innovations have been a feature of research associated with the testing of tidal stream turbines in the Bay of Fundy since 2009: new acoustic techniques for monitoring fish and mammal movements have been adopted and improved; new platforms that are robust enough to withstand the force of strong tidal currents have been developed to deploy sophisticated oceanographic devices; waves and birds are being monitored by radar; and more precise numerical models of turbulence and currents are being developed. While the focus of these contemporary studies is in limited areas – primarily at the FORCE[9] site in Minas Passage – the attempt to monitor and model the biophysical processes that are characteristic of the Bay of Fundy adds considerably to our understanding. It enables us to begin the process of forecasting future conditions as the Bay continues to change.

Expectations for the Future

The natural processes of change that have characterized the Bay for the last few thousand years – sea level rise, increasing tidal range, shoreline and seafloor erosion, etc. – will undoubtedly continue, and be exacerbated by the effects of global warming and any future human interventions. Increasing temperatures in both the atmosphere and the ocean will have several effects, including a reduction in the severity and persistence of ice in the macrotidal bays of the system. Since winter ice is a primary stressor on Upper Bay tidal mudflats, it is probable that the characteristic reworking of intertidal sediments that prevents persistence and dominance of longer-lived fauna will diminish. One expects that both saltmarshes and sediment-stabilizing macrofauna could increase in dominance. If this proves to be the case, the effects on shorebirds using the Upper Bay mudflats could be important. Until recently, it was believed that many of the shorebirds (and fish) visited the Upper Bay because of the abundance of invertebrates such as the mud-shrimp *Corophium volutator* which appear to be dominant where the sediments are disturbed each winter by ice. More recent studies have demonstrated that these birds are perfectly able to feed on the biofilm formed on the sediment surface. In either case, however, the conditions for shorebirds in this region could be very different in the future.

There is growing evidence that the distributions of several species, including the American lobster and North Atlantic Right Whale, are already changing as coastal water temperatures rise or food resources change. Not only does this represent a significant challenge for important fisheries of the region, but it is likely that the patterns of trophic relationships will also change. Warmer waters could also increase the

[6] Amos *et al*. 1992.
[7] Paterson and Daborn 1991.
[8] For *L*ittoral *I*nvestigation of *S*ediment *P*roperties cf. Daborn *et al*. 1991.
[9] Fundy Ocean Research Center for Energy.

success of invasive species, many of which (e.g., tunicates, crabs, algae) are already having serious effects on native populations. Forecasting such effects requires that we continue to improve our understanding of the biophysical dynamics of the Bay of Fundy system.

Local human activities will always be a factor. The strongly negative environmental effects of building causeways and dyking marshes have been recognized, leading to calls for the causeways to be removed, and the dykelands opened again to the sea. Such changes in themselves constitute further anthropogenic influences on the natural processes of the Bay. Because such structures have acted to protect the coastline from erosion, attempting to reverse the mistakes of the past could have more significant negative effects in the future, especially where human settlements have moved into the coastal flood zone.

All such decisions require the best possible understanding of the processes of the coastal zone. Since our present knowledge is still incomplete, and the ecosystem is undergoing continuing change, further coordinated research and monitoring are essential. In addition, it is imperative that the public at large has a more profound understanding of the nature of the Bay of Fundy and the probable effects of human activities. That is a role that BoFEP has played in the past, and which will become even more important in the future.

We shall not cease from exploration
And the end of all our exploring
Will be to arrive where we started
And know the place for the first time.
T.S. Eliot, *Little Gidding* (1935)

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2. Panel Sessions

2.1 Ocean Literacy and Awareness

The Panel

Chaired by Michael J.A. Butler, Director, **IOI-Canada**, based at Dalhousie University, the panel consisted of Magali Gregoire, Executive Director of the **Back to the Sea Society** and board member of the **Canadian Network for Ocean Education**; Tracey Dean, Director of Education at the **Huntsman Marine Sciences Centre**, in St Andrews, NB; Kerri McPherson, high school math and science teacher, including 'Oceans 11', at the **C. P. Allen High School** in Bedford, NS ; Anna Naylor, Manager of Learning and Development at the **Centre for Ocean Ventures and Entrepreneurship** in Dartmouth, NS; and Roland Chiasson, environmental educator and partner in the **Aster Group**, in Sackville, NB.

Premise

The Ocean is under significant stress; its health is fundamental to most life systems, and Canadians, in general, are woefully unaware of its importance.

Panel Presentations

Magali Gregoire, founder of The Touch Tank Hut on the Dartmouth waterfront, provided an example of actively engaging children in a hands-on introduction to local marine animals. Magali is also on the Executive of the Canadian Network for Ocean Education (CANOE). With 7 Working Groups and two successful conferences (the most recent was held in St. John's, Newfoundland in July 2018), CANOE is now considering the "Canadianization" of the 7 Ocean Literacy Principles. These Principles were initially articulated by a number of US organizations, including NOAA, National Geographic and the National Marine Educators Association.

The importance of field trips and hands-on activities to engage any grade level was emphasized by Tracey Dean, and by all of the other panelists. The programs at the Huntsman Marine Science Centre in St. Andrews exemplify this approach and its positive impact. To quote one of the Centre's Education Department's goals: "foster lifelong interest in science, by showing students it can be fun to learn scientifically through hands on activities".

According to Kerri McPherson, a high school science teacher, only three of the eleven courses in the high school curriculum in Nova Scotia contain references to the ocean, a significant oversight given Nova Scotia's branding as "Canada's Ocean Playground". This would confirm research that indicates that Nova Scotian youth have a limited knowledge of ocean concepts. Apparently the major challenges facing even interested teachers include a limited knowledge of those ocean concepts, a lack of teaching resources and time, and an already packed curriculum.

The provision of short courses on ocean literacy for in-training of recently graduated teachers is one obvious option. This would facilitate and encourage the integration of ocean awareness within the school system, at any grade and in any subject, without disturbing the current educational 'architecture'. Anna Naylor, representing the Centre for Ocean Ventures and Entrepreneurship (COVE), considered the panel topic from the perspective of the significant employment potential within marine industries. She pointed out that the original "Student Intentions and Perceptions Study", which included 14,000

participants from grade 6-9 in Nova Scotia, clearly indicated the lack of career awareness and the general negative views of ocean careers, such as fisheries. To address this situation the Marine People Partnership (MPP) develops and hosts professional development (PD) workshops for teachers to assist them to integrate ocean topics into their current curriculum, and to encourage ocean and career literacy.

The Aster Group, represented by Roland Chiasson, tackles the "lack of resources" complaint, so often heard from teachers. He, and colleagues, authored the excellent "**By the Sea - A Guide to Ecosystems within the Coastal Zone of Atlantic Canada** ". The Groups on-line database for education resources, entitled "Resources for Rethinking", focuses on curriculum materials that have a sustainable development focus. The "Great Minds Think Outside" is a hands-on, curriculum-linked, outdoor professional development program that gives educators the skills and resourced they need to teach their students outside whatever the subject matter.

The Take Away

Small and incremental progress re ocean awareness is being made within the schools and public generally but slowly.

The unavailability of appropriate resource material within the school system is a complaint of many grade school teachers. However, the excellent but little known "**By the Sea - A Guide to Ecosystems within the Coastal Zone of Atlantic Canada**", prepared for all grade levels and published in the late 90's, is rarely utilised. As discussed, this 15 module publication, which includes hands-on exercises, can be downloaded from the Fisheries and Oceans Canada Library website. The Guide is also available in French - **Au bord de la mer - Guide de la zone côtière du Canada atlantique**. The BoFEP **Fundy Issues** are another source of freely available information. Focused on the Bay of Fundy, they can be found on the BoFEP website (bofep.org). The IOI **World Ocean Reviews** have a global perspective, are jargon free and have excellent graphics. All five editions (to date) are free and downloadable or can be sent from Germany in hard copy free of charge.

A proposed Atlantic Caucus within the CANOE organization was discussed with the idea that it would encourage cooperation within the Atlantic Provinces and certainly facilitate an exchange of ideas. And if progress was made, perhaps the Council of Atlantic Ministers of Education and Training (CAMET), an agency of the Council of Atlantic Premiers (CAP), could be persuaded to provide support.

Conclusion

The active engagement with professionals within the provincial Departments of Education in Atlantic Canada would appear to be an essential first step. Only by assisting them to address the acknowledged lack of ocean awareness in the school systems of the Region can the numerous negative impacts of the current situation be addressed, namely, degrading ocean health; lost economic opportunities; and the accelerating and negative impacts of climate change. The panelists represent the dynamic resource that can catalyze the necessary educational "revolution", and so respond to what many believe is a looming crisis both regionally and globally.

Postscript

A great deal of activity re ocean awareness and literacy has been taking place concurrently with the BoFEP Workshop. A national initiative is underway involving such organizations as Dalhousie University, the Ocean Frontier Institute, OCEANA, the Ecology Action Centre, and many others from across Canada. A detailed plan of Action is in preparation. This program was undoubtedly assisted by the "Open Letter on Ocean Priorities for the Canadian Government", prepared at the "Canada's Oceans: Towards 2020"event at the Royal Ontario Museum in December 2017 and presented to the Prime Minister on June 8. One of the identified Action Items was as follows: "Ensure ocean literacy and conservation priorities are included in all K-12 curriculum systems in all provinces, territories and indigenous communities."

2.2 Information Use at the Science-Policy Interface in Decision-Making in the Bay of Fundy

Convenor: Environmental Information: Use and Influence (EIUI) research Program, School of Information Management, Dalhousie University, Halifax, Nova Scotia

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Panel Abstract: The world's oceans are increasingly threatened by pressures related to human activities along coastlines, including, living and non-living resource extraction and climate change. In Atlantic Canada, the Bay of Fundy region supports a rich biodiversity, including many species at risk (whales and sea birds), and non-living resources. The region is a major hub for shipping, mining, and tidal power activities. Many of the industrial and natural activities compete with each other, making coastal and ocean management very challenging. The Bay of Fundy is also a data and information rich area, with many databases and thousands of publications produced over the last century. Regional policy and decision-makers need relevant information to consider options, make informed decisions, and manage the many resource and environmental issues and risks effectively.

This panel described common challenges to information use in policy-making and existing and emerging methods to bridge the science-policy gap. The results of case studies conducted by the Environmental Information: Use and Influence research program at Dalhousie University, about information production, communication, and use in decision-making in national and international organizations, such as the Canada Department of Fisheries and Oceans and the Gulf of Maine Council on the Marine Environment, were highlighted. The panel also discussed the efforts by non-governmental organizations and the public to influence management and public policy decisions.

The panel addressed three main questions:

(1) Does information produced by governmental, intergovernmental, and non-governmental organizations reach policy and decision makers in an efficient and timely manner?
(2) What are the enablers and barriers to the use of marine environmental information at the science-policy interface?
(3) Despite the continued effort to expand knowledge bases, how can existing information be used better, to inform policy- and decision-making aimed at seeking solutions to serious coastal and ocean problems?

Bertrum H. MacDonald – "Understanding Information Use in Decision-Making for Coastal and Ocean Governance"

Today, information is supplied predominantly by digital sources. Nearly four billion internet users create and share enormous quantities of information through websites and social media, and a new research paper is published approximately every 20 seconds. The resulting information-overload raises the question: what if someone had already determined how to solve the most pressing environmental issues, but the information is buried where no one will find it?

The Bay of Fundy region is facing major issues involving decision-makers and researchers. For example, right whale populations are trending toward extinction, early tidal energy demonstrations have polarized members of the public, and management questions remain about the future of regional dykelands. While it is generally agreed that decision-makers should use the best available information, decision processes tend to be complex, involving numerous actors and interactions. Information enablers and barriers affect communication as does the cultural, economic, institutional, and political contexts. Thus, multiple questions emerge: Which information can be trusted, and how can decision-makers be confident that they are receiving and applying the best available information? If only the interested public is engaged, how can communication be improved to draw the wider public into decision-making? If all stakeholders (i.e., governments, researchers, industry, NGOs, First Nations, community groups, and citizens) should be involved in the decision-making process, how can we ensure relevant and credible information is available to all groups? How can individuals and organizations acting as bridgers and brokers be valued for their role in facilitating information exchange?

Suzuette S. Soomai – "The Science-Policy Interface in Fisheries Decision-Making"

In this study, direct observations of meetings of the Canadian Science Advisory Secretariat (CSAS) in Fisheries and Oceans Canada (DFO) and interviews were used to develop an understanding of information pathways among scientists and managers. The data clearly showed that CSAS research is completed to provide specific scientific advice to respond to decision-makers' needs, using internal grey literature and an internal peer-review process. Information communication is iterative, and trust relationships are essential to the use of information, which is seen as credible, relevant, and legitimate. However, some trade-offs exist. Scientific advice is limited to the management questions posed, and useful information and relevant external actors may be overlooked. Additionally, the complex organizational structure of CSAS can be a barrier to information use in decisions, and the CSAS operations currently do not easily accommodate ecosystem approaches to management or climate change considerations. This study shows that while trade-offs may also figure in other jurisdictions, such as the Bay of Fund region, understanding information flow among actors could lead to improved

information production and communication practices, enhancing information uptake in decision-making. Clearly defined decision-making processes that include diverse stakeholders could enhance the use of information and foster trust relationships between researchers and managers.

James D. Ross – "Awareness and Use of State of the Environment Reports: A Study of the *State of the Scotian Shelf Report*"

The *State of the Scotian Shelf Report*, a major state of the environment report, was published between 2011 and 2013 by the Canada Department of Fisheries and Oceans. Created in a modular format of individual theme papers, the solely digital report is hosted on a COINAtlantic server. Initially intended as an updatable report, this revision process was suspended when the Eastern Scotian Shelf Integrated Management Initiative was terminated by the federal government. As the report provides a major synthesis of knowledge about the Scotian Shelf, a study was conducted to gauge awareness and use of the report since its publication. A mixed methods approach, using web analytics, citation analysis, an online survey, and semi-structured interviews, was used. Although the Report was infrequently cited (mainly for background information), it was frequently accessed online. The survey and interview participants identified the report as especially useful in a variety of contexts, and they emphasized the importance of sustained promotion of the report to encourage use of the information. The results of this study – including the report – could prove significant, as the Bay of Fundy and Scotian Shelf are being considered as a potential Large Ocean Management Area. A similar state of environment report completed for the Bay of Fundy may therefore be useful, especially if it is effectively promoted.

Rachael Cadman – "Marine Protected Areas: How eNGOs Use Information and Relationships to Advance Conservation Decisions"

Recently, environmental NGOs (eNGOs) have taken on more prominent roles in environmental governance. In 2015 the Canadian federal government sought the assistance of eNGOs in its plan to reach conservation targets of protecting 5% of Canada's ocean by the end of 2017, and 10% by 2020. A more open and collaborative relationship between eNGOs and the government developed. This study examined the work of WWF Canada and the Ecology Action Centre regarding three marine protected areas (MPAs). Data were collected through direct observations of meetings and day-to-day operations of the eNGOs, a review of email exchanges concerning the conservation areas, and interviews with individuals from each organization. The data showed two important themes: *actions* of the organizations during their MPA efforts, and *interactions* with individuals and groups external to the eNGOs. The eNGOs used various tactics, including hard (public-facing) advocacy focused on achieving clear results, soft (non-public-facing) advocacy focused on influencing processes, information gathering, and administrative activities. In addition, eNGOs interacted with a variety of groups, including other eNGOs, other stakeholders (such as in academia or industry), and government. These NGOs fulfilled a boundary role to facilitate information exchange and knowledge co-production among actors, and a bridging role to create opportunities for knowledge sharing and relationship building. The results suggest that eNGOs working on issues in the Bay of Fundy should be better valued for their boundary/bridging work and eNGOs could assist governments to improve the relevance, credibility, and legitimacy of decision-making in the region.

Simon R. Ryder-Burbidge – "Investigating Ocean Connectivity and Coastal Values in Coastal Communities"

Many people have special places that they are emotionally attached to and often return to throughout their lives. They feel a connection to such places, experiencing a sense of physical relationship with the natural world. However, management of marine environments does not usually reflect how people personally value such settings. Furthermore, misperceptions of the ocean have previously influenced decision-making and continue to do so. Therefore, understanding how the ocean is perceived and valued by individuals could be important in ocean governance. To investigate whether community values are currently reflected in marine governance planning, a survey of residents of Falmouth, Massachusetts was conducted, focusing on coastal change, access and recreation, conservation and seafood, marine economy, ocean knowledge, and coastal intangibles. The respondents overwhelmingly referenced intangible, personal concepts to express their most valued connection to the ocean. This outcome is consistent with relational values where coastal ecosystems become an extension of interpersonal relationships. The results merit consideration in the Bay of Fundy region regarding how relational values should be formally integrated into decision-making. In ongoing issues (such as with tidal energy), it seems that public perceptions play a role in governance. Management practices and decision processes would likely benefit from better public engagement in the region that takes place-based values into consideration.

Several points were raised in the discussion period:

- With regard to a public campaign that highlighted the perceived threat of tidal turbines to fish populations, an audience member stated that the campaign was (at least in part) meant to catch the attention of managers/government, rather than aimed at misconstruing information. This observation highlights the importance of engaging the wider public in management decisions about the Bay of Fundy and clearly communicating research information especially where a risk of misperception about information can occur.

- A question about how the CSAS process is conducted also highlighted public perceptions about research and management in the Bay of Fundy region. Research and decision processes are not always perceived as credible, relevant, and legitimate. Thus, emphasizing these criteria in the information used in decision-making is important.

- With regard to information access and sharing, an audience member noted that a disconnect can occur between the personal context in which information is accessed and the professional context in which information is shared. People can isolate themselves from others in professional settings, rather than engaging in relationships in decision-making processes. This observation raised the question about how to overcome institutional barriers to information communication.

- In discussion on bridging and boundary work it was noted that both individuals and organizations taking on these roles are often undervalued. Several participants suggested attention should be focused on the importance of these science communication activities to formalize their significance more effectively.

- The importance of engaging indigenous communities in research and decision-making was discussed, noting that meaningful improvement is needed in the Bay of Fundy region.

2.3 Future Research in the Bay of Fundy and BoFEP's Role

Chair: Marianne Janowicz (BoFEP)

Panelists: Graham R. Daborn (Acadia University), Peter G. Wells (Dalhousie University), Sarah Chamberlain (BoFEP), Joshua McNeely (Maritime Aboriginal Peoples Council), Frederick J. (Jack) Fife (DFO-SABS)

The mission of the panel: This panel will discuss future research needs in the Bay of Fundy, considering current and emerging issues affecting the bay. The focus of the discussion will be the role of BoFEP in facilitating future research and in other areas, especially communications. Should BoFEP's role be promotion and coordination of research? Or solely communication on Fundy environmental issues, or something else? As an organization that is primarily run by volunteers, and funded by contracts and donations, how can BoFEP continue to have a meaningful role in Fundy environmental issues? All workshop participants are invited to contribute to this discussion.

A. The Panel Discussion

There was considerable discussion ahead of the panel as to future Fundy research and BoFEP's role, and the questions to consider by the panel. The panel Chair Marianne Janowicz presented the panelists with several questions and assigned people to them. Time was very limited to prepare the answers below, so they were augmented by the panelists and the Editors, post workshop.

1) **What is needed for long-term conservation and protection of the Bay of Fundy? [Graham Daborn]**

Answer: There are at least three major needs:

a) We need a vision for the Bay of Fundy (the whole ecosystem) that stretches out 20-30 years. This would include an ICM (integrated coastal management plan) and follow-up program for Fundy. We clearly need to address the impacts of climate change and determine what we can change in our behaviour to ameliorate our impacts. This should include recognizing that there may be ecosystem changes over which we have no control.
b) We need to address and solve jurisdictional problems that hamper solutions to pressing issues facing the bay. Involve the municipalities and Aboriginal peoples/First Nations in this quest.
c) Sort out our priorities and initiatives with government. There seem to be new initiatives every year, which is unnecessary! Use all the various tools available for conservation and protection to address the problems.

2) **Engaging the public and the policy makers is often identified as important to long-term conservation and protection. In your opinion, have the publics and the policy makers been adequately engaged about the state of the Bay of Fundy, its health, and its future? [Peter Wells]**

Answer: Yes and no. The key word is "adequately"! Since the mid 1990s, there have been many conferences and forums engaging the interested public (as distinguished from the general public). Many useful discussions have occurred and suggestions made and recorded (see the

2014 bibliography of GOMC – Gulf of Maine Council - publications[10] – and the BoFEP website for a record of our workshops and forums, amongst others). But we seldom attract the decision and policy makers to such conferences and forums (we tried for this panel!). One big exception has been the conferences organized by the GOMC and RARGOM (Regional Association for Research on the Gulf of Maine) – senior government people often attend these, as well as the annual Council meetings of the GOMC. We have also had meetings such as the 2004 Tides of Change Conference in St. Andrews, NB,[11] and the 2009 Gulf of Maine Summit.[12] But have we done enough – no. We do need to listen more to the voices of both the interested/concerned publics and the policy makers, together in the same room. We need to engage the latter group much more effectively and more frequently.

Audience query/question: We need to identify actionable items for coastal communities, and BoFEP needs to network with other groups and be inclusive. Comment (post-workshop): BoFEP has done so in the past, with the focus in the early 2000s on the Minas Basin communities and having a broader base represented on our steering committee; unfortunately, this has slowed in recent years due to funding challenges and the shortage of volunteers to run focussed working groups.

3) **The Bay of Fundy environment, and our use of it, is continually changing. It is important that we identify issues as early as possible to be most effective at addressing the problem, as well as effective with human and financial resources, particularly public resources. What are the best approaches to collectively identify the new issues to the Bay of Fundy that require research? [Joshua McNeely]**

Answer: We have made the challenge to "caring for the Bay" ourselves, taking that responsibility and looking at the bay holistically (i.e., as a whole ecosystem). We should all get together and share our collective experiences and list what we consider to be "the threats" to the Bay. When we get together, we should also learn about ideas and methods that have been tried around the world to identify and address emerging issues. This discussion should involve the coastal communities – how we want to address the threats that the communities feel are the priority. We should involve the resource users of the bay, the fishers. We need to identify some actionable items which we need government involvement and place those in front of the politicians for them to also take up our causes, particularly funding. Most important, for BoFEP to be validated by communities as a voice for the Bay of Fundy, we need the space, time and place to engage with them ask for their opinions about the key issues. We should consider more activism. And we need an ICM (integrated coastal management) approach to managing the whole bay, one that is equitable.

Audience query/question: It was pointed out that distinguishing emerging issues from legacy issues is important (according to the speaker, legacy issues are "those that have resolution but the public fails to acknowledge that change has occurred or is in progress").

[10] GOMC Bibliography, produced by the EIUI Research program, Dalhousie University. 2014.
[11] Pesch, G. and P. G. Wells. Eds. 2004. *Tides of Change Across the Gulf. An Environmental Report on the Gulf of Maine and Bay of Fundy.* Gulf of Maine Council on the Marine Environment, Augusta, ME. 81p.
[12] Stephenson, R.L., J.H. Annala, J.A. Runge and M.Hall-Arber. Eds. 2012. Advancing an Ecosystem Approach in the Gulf of Maine. Proceedings of the Symposium "Gulf of Maine Symposium: Advancing Ecosystem Research for the Future of the Gulf", Held in St. Andrews, New Brunswick, Canada, October 4-9, 2009. Amer. Fish. Soc. Sympos. 79. 415p.

Editor's note: the two general types of issues (legacy, emerging) are well defined in the literature but perhaps (likely?) not well understood or appreciated by the general public, or indeed by the decision makers.

4) **What activities/research could BoFEP conduct to help you and the other partners to promote the integrity, vitality, biodiversity and productivity of the Bay of Fundy ecosystem, and to protect the social well-being and economic sustainability of its coastal communities? [Jack Fife]**

Answer: Continue the biennial Bay of Fundy science workshops. We also need a supply of educational materials and speakers, so as to reach out to people "who have a thirst for knowledge". We need to have more interaction between the scientists who produce much of the information and the teachers, especially bringing the teachers into the research institutes from time to time. And we need to update and complete the Fundy book, a long-term project of BoFEP.

Audience query/question: On the question of information about the bay, one audience participant mentioned the need to update the BoFEP fact sheets (a need well recognized by the BoFEP management team), and that we have missed engaging tourists through interpretive displays, visuals and mobile apps. It was also stated that the Oceans 11 curriculum is archaic and that we should be providing information to children in their earlier stages of development. Another member of the audience mentioned the need for BoFEP to play the coordination role and to maintain contact with workshop attendees, especially those present for this panel discussion.

5) **BoFEP currently holds biennial workshops, produces the Fundy Tidings Newsletter, and conducts small projects from time to time. Would you like BoFEP to play a bigger role in addressing emerging issues for the bay? Are there other major activities that you would like to see BoFEP undertake? [Joshua McNeely]**

Answer: This question went out to the broader audience at the workshop…….(see notes below)

6) **Over 20 years ago (November 1997), BoFEP was established as a virtual institute. Is the BoFEP model still important/relevant to your [the audience] work and interests? [Sarah Chamberlain]**

Answer: "The BoFEP model is a wilted bush". It is outmoded, i.e., out of date. Greater engagement is needed from "the top" (left unexplained). The whole virtual institute model needs to be re-examined. [See discussion below].

B. General Discussion – BoFEP's Role

There was an active and enthusiastic exchange between the audience and the panelists as to how BoFEP should proceed in the future in support of the Bay of Fundy as a whole and its coastal communities. Major points and suggestions follow, organized by theme or activity:

1) **Networking and Coordination:**
    a) Link/network all the persons and groups interested in the Bay of Fundy. The basics about the Bay of Fundy should be available in a document with accessible language.
    b) Stitch this Fundy network together. Maintain the relationships formed at this workshop. BoFEP should be a coordinating body. (Donald Kilborn)
    c) Where do we stand re our association with ACCESS (Atlantic Canada Coastal and Estuarine Science Society)? Are we an enabler of Fundy science or a competitor with such a group? (Jeff Ollerhead)

2) **Information and Communication:**

    a) In identifying important environment issues, focus on the magnitude of the problem, not its longevity. (Sarah Chamberlain)
    b) The Fundy Issues book is a good idea but the current fact sheets are dated. Also use visuals for communicating messages, and engage the tourism departments. (Danika van Proosdij).
    c) For these workshops, film them. We need the record. Make the workshop into a series of Webinars.
    d) For these workshops, a student discount is needed to facilitate their participation!

3) **Education:**

    a) Consider running summer camps on the oceans and the bay, for ocean educators. (Graham Daborn).
    b) The Oceans 11 program in the NS schools needs information packages.
    c) There should be an Atlantic caucus within the group CANOE (Canadian Ocean Education Network). We need a training program for teachers on the topic of oceans. Use the current documents on the Bay of Fundy to contribute to this. (Mike Butler)
    d) Consider the GOMI (Gulf of Maine Institute) as a suitable model for ocean education. (Graham Daborn)

4) **BoFEP Organization and Funding:**

    a) To operate, BoFEP needs grants and more people. Seek funding from industry. Consider charitable status (note: we have considered it in the past and decided against it, because of the time and money necessary to maintain charitable status as well as federal not-for-profit status). (Jeff Ollerhead).
    b) Reconsider the BoFEP model. Seek foundation monies. Seek industry monies, related to their issues.

3. Contributed Paper Session Abstracts

Abstracts and extended abstracts for contributed paper sessions are listed in the order presented by session. The full Workshop program is available at http://www.bofep.org/wpbofep/wp-content/uploads/2018/05/Program_REVISED_for_Web.pdf

Emerging Environmental Issues in the Bay of Fundy and Gulf of Maine

Peter G. **Wells**
International Ocean Institute-Canada, Dalhousie University, Halifax, NS (oceans2@ns.sympatico.ca)

This talk set the stage for discussion around the theme of the 12th BoFEP Bay of Fundy Science Workshop – *A changing Fundy environment: emerging issues, challenges and priorities*. It briefly presented an overview of some of the emerging environmental issues (already recognized or newly recognized) in the Bay of Fundy and northern Gulf of Maine. A report is being prepared for Environment and Climate Change Canada (ECCC), organized as per the DPSIR (driver-pressure-state-impact-response) framework, simplified as driver/pressures, state/impact and societal response/actions. The report supports the goals and objectives of ECCC's ongoing Gulf of Maine Initiative (GMI) in helping to enhance and share knowledge of stressors to the Gulf of Maine ecosystem. It is a sequel to a previous theme paper on this topic prepared for the Gulf of Maine Council on the Marine Environment (see Wells 2010 at www.gulfofmaine.org/2/resources/state-of-the-gulf-of maine-report) and a talk on emerging issues given at Coastal Zone Canada 2014 in Halifax.

Since the CZC Conference of 2014, an active information file has been kept of Fundy marine environmental issues requiring revisiting (e.g., the various impacts of climate change, threats to biodiversity from invasive species) or appearing as new regional marine issues (e.g., right whale mortalities, plastics/micro-plastics pollution, changes in species distribution). Highlights of the report were given. The aim is to stimulate discussion about the ecosystem health of the Bay of Fundy, the important emerging issues, and the immediate and longer term priorities for research, communication, integrated coastal management, and marine policy development, in the rapidly changing oceanic environment. It is important that new studies, especially those conducted through the GMI program and the Gulf of Maine Council on the Marine Environment (GOMC), stay timely and relevant,

The final report was submitted to ECCC in July 2018, identifying some of the major EIs for the Bay of Fundy and northern GOM. They include the primary driver of climate change (including rising sea temperatures and ocean acidification, and future adaptation and mitigation), and the main topic of the upcoming Gulf of Maine 2050 Symposium, November 2019, in Portland, Maine. A number of other issues are considered a priority - underwater noise pollution, underwater munitions (not often considered), impacts of expanded open water coastal aquaculture, impacts and control of plastics and micro-plastics, the potential region-wide effects of tidal power development, the spread of natural toxins, the impacts of invasive species, and cumulative ecological change. ECCC will shortly be issuing a reviewed version of the report for discussion at the GOMC and other regional fora, hopefully stimulating discussion, new and innovative research and monitoring on pressing Fundy environmental concerns, and timely policy and management action wherever possible.

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3.1 Fisheries Ecology & Management

Chair: Joshua McNeely, Maritime Aboriginal Peoples Council, Truro, NS

Seabird Diets as Bioindicators of Atlantic Herring Recruitment and Stock Size: A New Tool for Ecosystem-based Fisheries Management

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Ecosystem-based fishery management requires understanding of relationships between exploited fish and their predators, such as seabirds. We used exploratory regression analyses to model relationships between Atlantic herring (*Clupea harengus*) in the diet of seabird chicks at nine nesting colonies in the Gulf of Maine, and four types of fishery- and survey-derived herring data. We found several strong relationships which suggest spatial structuring in herring stocks and likely patterns of herring movements before they recruit into the fishery. Some types of herring data seldom used in stock assessments – notably acoustic surveys, fixed-gear landings, and weight-at-age – correlated as strongly with seabird data as more commonly used series, such as mobile-gear landings and modeled spawning stock biomass. Seabird chick diets collected at specific locations thus offer a promising means to assess the size, distribution, and abundance of juvenile herring across a broad area prior to recruitment, which is a major source of uncertainty in fisheries. Common terns (Sterna *hirundo*) showed the most potential as a bioindicator, correlating well and showing consistent spatial patterns with 11 of 13 fishery data series.

Atlantic Herring (*Clupea harengus*) Stock Depletion off Southwest Nova Scotia and Humpback Whale (*Megaptera novaeangliae*) Mortalities

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Atlantic herring constitute the most important prey for humpback whales in the extended outer Bay of Fundy (oBoF). Many of the humpbacks following the westernmost seasonal migration route in the North

Atlantic target this area for summer-fall feeding, and others feed as they move through it to forage farther north. During autumn humpbacks start to move south, probably feeding opportunistically as they go. Populations of both species neared collapse in the region in the late 1970s, following several decades of over-fishing and whaling. With sovereignty, regulatory and management changes, the recovery of both species began in the 1980s. Herring reached a peak in Canadian waters in the early 1990s.

By the early 2000s people began to express concern that seine fishing was again overexploiting herring off SW Nova Scotia. This general perception continues, while the prevailing institutional worldview is that the herring, although a "stock of concern", are fished in a sustainable manner. Deaths of humpback whales, all causes, have increased dramatically off much of the east coast of North America in the last few years. The US agency NOAA declared the deaths in 2016-2017 an "unusual mortality event" (UME). There exists an uneasy sense among many people that starvation now also causes or contributes to many humpback deaths along this coast. The general institutional position is again that, human-caused entanglements and ship-strikes aside, humpback whales off the east coast are "not at risk" in the face of other potential threats.

In this study I investigate the characteristics of selected decadal temporal trends, from the perspectives of ecological resistance and resilience in interactions between herring and their predators - humpbacks and humans - in the oBoF. The extent and characteristics of stock depletion by way of seine fishing are established, using fishery landings as an indicator, proportional to herring abundance. By using landings to represent abundance, changes to the major food source for humpbacks also equates to human impacts on the herring-humpback interaction. Highly visible localized herring kills in 2016 provided density-independent sampling events for comparison. I then examine the probability that 'unexplained' near-shore humpback whale deaths in and contiguous with the region resulted from starvation because of herring over-fishing, during the latter half of the study period. Results are discussed in relation to fishery science, management, end-use of fisheries products and ecological conservation.

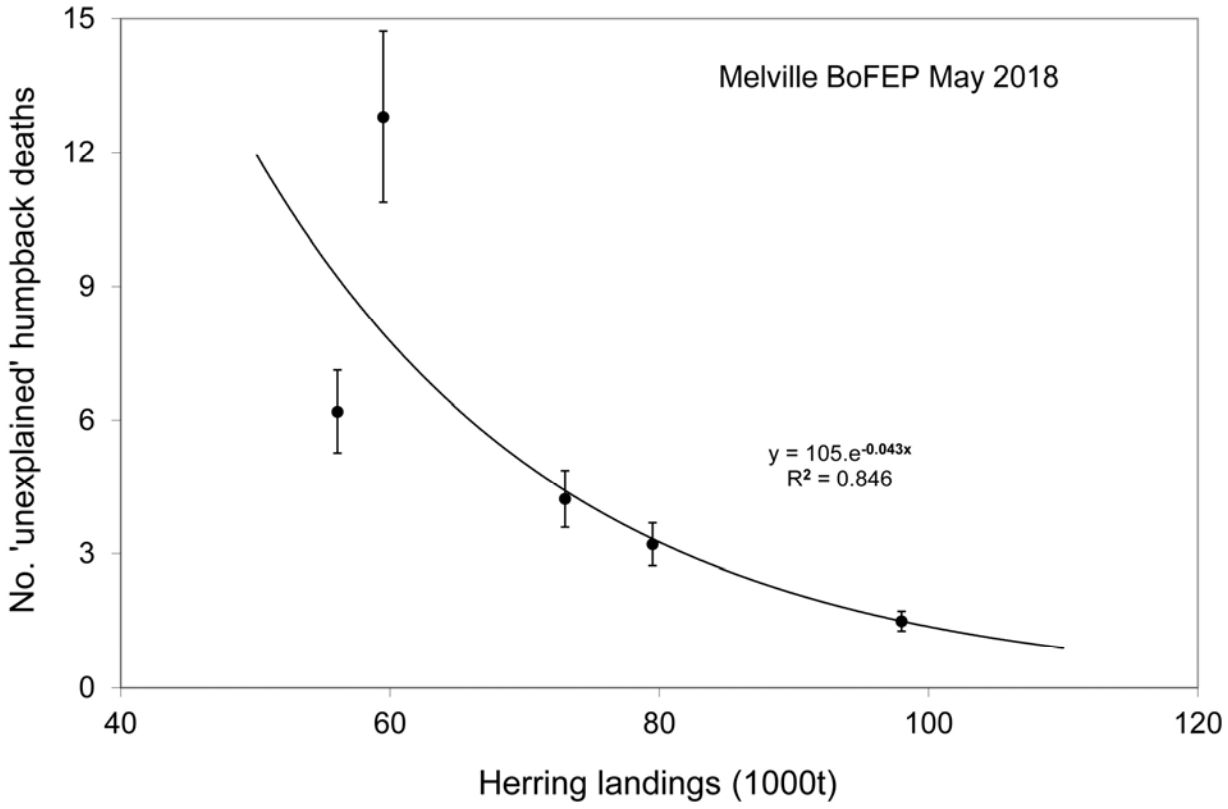
The approach in the study is of an experiential nature, drawing on relevant accumulated empirical data and credible observations. Landings and other data for the herring analyses were obtained from DFO and the State of Maine. I use the landings reported for the Canadian fishing area Scotia-Fundy (or synonymously, 4VWX+5Y) to represent the extended oBoF. Although the extended oBoF is only a part of Scotia-Fundy, few of the Scotia-Fundy herring are caught outside of the extended oBoF. Maine data are also analyzed, since the small NW corner of the oBoF lies in Maine waters. Observations of local herring kills in SW Nova Scotia and other herring-related events were collated from myriad sources. Humpback death data were derived from accounts in the literature, DFO, NOAA and ancillary sources, and means calculated and grouped in 3 year 'bins'.

Decreasing herring landings indicate a serious stock decline of 60% in the extended oBoF since 1990 or, by way of linear approximation 2.3% y^{-1} over 26 years. The small rate of decline over such a protracted period suggests moderate ecological resistance to insults from the removals via fishing. The temporal trend of landings from Maine waters parallels that of Canadian waters. Indicators such as CPUE and acoustic metrics do not contribute to abundance analyses, nor does TAC. Abundances and body sizes in the localized SW Nova Scotia herring kills are consistent with the evidence of stock depletion. Few herring reach the age of 5 years, at which point 100% of herring are mature. The residual herring stock in the extended oBoF is in a precarious position, given the decadal over-fishing, elimination of reproductive age classes, and major historical losses of spawning grounds to salmonid net-pen aquaculture.

An exponential increase in near-shore humpback whale mortalities occurred from 2003 to 2017, between Cape Hatteras NC and the Gulf of St. Lawrence. Most of the deaths were juveniles and occurred in winter or spring. The number of deaths should start to decrease in 2018 because many of the juveniles are now dead, and adult females may reduce fecundity levels in view of the fact that there is increasingly less food. However, the deaths exceeded allowable potential biological removals (PBR), even though population numbers have increased over the last 15 years. These losses are also similar to those from entanglement and ship-strikes, which exceeded PBR limits. Thus the deaths and any reproductive responses tax humpback resistive abilities, risking the latitude or potential to absorb any additional negative pressure on the population. This course of discussion does not even consider the lost cultural investment of teaching calves migration routes and feeding ground attributes.

Humpback whale mortalities rose sharply as herring landings dwindled (Figure 1), evidence of a loss of structural resistance in the humpback population at the current low herring abundances. With many of the dead juveniles showing evidence of malnutrition, starvation because of herring over-fishing must have contributed to the humpback deaths. A straightforward mechanism accounts for the geographic distribution of humpback carcasses. Whales which do not acquire enough to eat in northerly waters during the warm seasons eventually start to move south, but succumb to lack of nourishment and die somewhere along the way. The diminished nature of different population attributes, leading especially to the precarious position of the herring as prey for humpbacks, calls into question the resilience of this two-predator one-prey system.

Figure 1. Observed 'unexplained' humpback deaths in near-shore waters (mean year^{-1}, 3 year 'bins'), Cape Hatteras US to Gulf of St. Lawrence Canada 2003-2017, plotted against extended oBoF herring landings calculated in a similar manner.



Adequate science should be sufficient to bring about change in the way humans interact with these two species, but it is not. Suspect science inputs (e.g., acoustic metrics) aside, impotent management, inappropriate politics and cavalier herring-product uses all play deleterious roles in human interactions. Other species such as northern bluefin tuna and the Atlantic puffin in the extended oBoF are heavily affected by the herring fishery as well. The excessive and wasteful use of herring as bait in the lobster fishery, ostensibly to grow market demand for lobster in Asia, is untenable. Other end uses, particularly the production of aquaculture feed and pet food, are simply unethical. Current fisheries media often turn to conversations of landings and dollars, without mention of any costs whatsoever. Far more quality jobs are at stake in the current fishery regime than if the herring fishery was curtailed. The smothering presence of economic influences does not augur well for the conservation of herring-dependent ecosystems, including - ironically -all the attributes which generate economic benefits.

Acknowledgements

I thank all the people who provided logistical bits which facilitated the production of this work, including production expertise, photographs, documents, information leads and general support. Organizations in this regard include FEWR, FCDA and BIWSC. A list of selected references is available from the author upon request.

Comparison of the Physical Characteristics of Two Populations of Atlantic Sturgeon in Minas Basin: Kennebec and St. John Distinct Populations Segments

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Approximately 9,000 Atlantic Sturgeon, *Acipenser oxyrinchus oxyrinchus* Mitchill, 1815 aggregate in Minas Basin, Nova Scotia during the summer to feed on the rich abundance of bethnic invertebrates. Since 2010, the Coastal Ecology Lab at Acadia University has collected data regarding the stock composition, feeding behaviors, and movement patterns of threatened and endangered Atlantic Sturgeon in Minas Basin. DNA analysis indicated that 61% of Atlantic Sturgeon in Minas Basin originated from the Saint John River, 34% originated from the Kennebec River, and 2% were from the Hudson River, with the remaining originating from the James River. The aim of this study was to combine acoustic telemetry data and genetic data of Atlantic Sturgeon captured, tagged and released from 2010-2014 in Minas Basin, to determine if there is was a difference in the physical characteristics, or migration timing of the Saint John River and Kennebec River origin fish. Using an independent samples t-test measures of fork length between the Kennebec (mean= 135.64cm, sd= 16.241, n=81) and the St. John population (mean = 127.13cm, sd= 24.091, n=135) were compared. There was a significant difference in fork length between the two populations (t= 2.7383, df= 211.02, p=0.0067). The differences in the size of Atlantic Sturgeon entering the basin between the two populations could indicate that these populations migrate through the Basin at different stages in their life cycle. Having a better understanding of differences between distinct populations is needed to implement proper fishery regulations to conserve this species.

Nutrient Transfer: How Marine-Derived Nitrogen and Phosphorus from Alewife (*Alosa pseudoharengus*) Spawning Migration Benefit Freshwater Wetlands in Atlantic Canada

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Alewife (*Alosa pseudoharengus*) migrate from the ocean into freshwater ecosystems annually to spawn. During their migration, Alewife transfer important nutrients (mainly nitrogen [N] and phosphorus [P]) in the form of reproductive matter, carcasses, and excretory wastes that help maintain productive coastal wetland ecosystems. The aim of this project is to understand how Marine Derived Nutrients (MDN) from spawning Alewife integrate into the food web of two lakes in New Brunswick and Nova Scotia. We will use Stable Isotope Analysis (SIA) to determine the spatial and temporal distribution of marine-derived N and P in freshwater ecosystems from the Alewife spawning migration. SIA of samples from freshwater zooplankton will provide information on MDN distributed in the water column from excretion. Samples from macroinvertebrates (Leeches *Hirudinea* and snails *Gastropoda*) will provide information on MDN input from decaying carcasses, sperm and eggs. I hypothesize that MDN levels of three groups (zooplankton, leeches and snails) will be elevated in the spawning area, then gradually become uniform throughout the lakes and dissipate as the year progresses. This pattern will be repeated annually. Results will be crucial for wetland and anadromous fish conservation efforts by determining how MDN are integrated into the freshwater food web and how long they remain a driver of production for those food webs. The data from this project will be used by wetland conservation organizations and fishery managers to protect anadromous fish and their spawning habitats.

Sea Cucumber (*Cucumaria frondosa*) Population Dynamics for Improved Resource Management within Fishing Areas

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With global demand for sea cucumber products increasing and tropical stocks collapsing, it has opened a unique economic opportunity for Atlantic Canada where *Cucumaria frondosa*, or the Orange-Footed Sea Cucumber, are plentiful. *Cucumaria frondosa* is a filter feeding sea cucumber that ranges in colour from purple to orange and has ten orange tentacles it uses for feeding. These sea cucumbers grow slowly, reaching a maximum length and weight of 50cm and 500g respectively. Sea cucumber fisheries have been developing off the coast of Eastern Canada for the past decade or so, but their population dynamics remain largely understudied. Fisheries in Newfoundland and Labrador, Quebec, New Brunswick, and Nova Scotia, are managed separately, with some management regimes based on more and better data than others. In the Passamaquoddy Bay, many studies have been carried out looking at life history characteristics of *C. frondosa.* Although this life history information is central to proper management, other critical metrics for determining population dynamics are still lacking. To properly manage these sea cucumber populations, abundance and biomass, which are crucial to calculating catch quotas, must be estimated. These parameters must be understood to allow for sustainable catch in the long term. To make these estimates, we are conducting drop-camera video surveys of the fishing areas on the Scotian Shelf. With these videos and still photography we can calculate both abundance and

biomass, as well as look at habitat preferences and proximity to predators. These new assessment methods, in conjunction with data from ongoing surveys, may be useful in other sea cucumber fisheries in eastern Canada as well, including in the Bay of Fundy.

Small Harpacticoid Copepod the Principal Prey of First Feeding Larval Striped Bass (*Morone saxatilis*) in the Shubenacadie River Estuary

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To determine the zooplankton abundance and potential prey of larval striped bass in the Shubenacadie River Estuary, quantitative plankton net tows were conducted in the upper-estuary (river km 25 to 40) every 3 to 4 days from May–July 2016–2017. Striped bass eggs hatched in about 2 days after spawning and larvae reached the first-feeding stage in about 5 days (5–6mm total length, TL). Highest mean weekly abundance of post-yolk-sac larvae was 463/m^3 May 29–June 4, 2016, and 595/m^3 June 12–18, 2017. Larvae failed to grow and had empty stomachs for about two weeks due to lack of suitable prey. The first prey items in the stomach among 99% (out of 870) of larvae was a small (<1mm TL) adult stage harpacticoid copepod from the family Ectinosomatidae and could possibly be *Halectinosoma* sp. or *Pseudobradya* sp. Mean peak abundance of this copepod was 200–250/m^3 in salinities of 1.1–2.0ppt during June 2017. Once the striped bass started feeding and growing, other copepods in the stomach contents included *Diacyclops bicuspidatus*, *Pseudodiaptomus pelagicus*, and *Coullana canadensis*. The copepod diversity of the macrotidal Shubenacadie River Estuary contrasts with stratified coastal striped bass nursery habitats along the Eastern seaboard where *Eurytemora affinis* is the main prey.

Fallen Angelwing (*Barnea truncata*), a Disjunct Mollusc Species of the Minas Basin and Bay of Fundy: Known Biology, Substrate Constraints, Coarse Scale Distribution and Conservation Status

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The Fallen Angelwing (*Barnea truncata*), found in the Minas Basin and Cobequid Bay is mollusc species with an Amphi-Atlantic Distribution. The Canadian occurrence approximately 500 kilometers from the nearest (southern) occurrence is restricted to a single substrate type in limited portions of the intertidal zone of the basin and bay, a Triassic era mudstone. Due to its inability to move once it has settled, it is subject to site-specific elimination through changes in substrate deposition and sediment movement. As such, its occurrence should be considered a significant indicator of both local scale as well as gross scale changes in energy regimes/sediment deposition within this ecosystem.

As of May, 2017, it is listed as threatened under the *Species At Risk Act*, consequently clear knowledge of its current distribution, life history traits and habitat constraints is essential in the evaluation of activities which may result in changes in energy regimes and patterns and in sediment re-distribution

within the ecosystem. A review of its known biology, substrate constraints, coarse scale distribution and conservation status is presented.

3.2 Integrated Coastal Management

Chair: Levi Cliche, Clean Annapolis River Project, Annaoplis Royal, NS

Common Issues, Common Goals: Increasing Collaborations in Habitat and Resource Conservation

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A history of overexploitation in regional fisheries and vulnerability to effects of climate change form the basis for growing support of an anticipatory approach to management of marine resources within an ecosystem-based framework. To boost the effectiveness and adherence to marine policies, conserve resources for future use, and combat climate-related environmental changes, knowledge holders must be better engaged in current issues. The disconnect between community members with local and traditional expertise (LEK) related to Minas Basin fisheries and watersheds, and resource management agencies, forms a barrier to effective management. I propose to collect, compile, and assess LEK in conjunction with standard scientific principles of ecosystem management related to fisheries. The directive will support creation and adoption of integrative and collaborative protocols for community-level resource oversight and knowledge sharing. Specifically, the research will focus on solutions for better fish passage at tidal barriers in Minas Basin. Extrapolation and application of LEK data to explore changes in fish distributions, demographics and fisheries data collection methods is of growing significance and of regulatory interest.

The significance of this project includes a record of fisheries LEK in the local waterways with significant fish migration activity and barriers to habitat access. Development of relationships between LEK and various environmental indicators is a critical component of the research and may help create standards for using LEK along with long-term data trend compilation. Based on these relationships, capacity building for fishers to be active in cooperative management will be explored. The outcomes include compilation of data to inform target and non-target fisheries conservation actions, increased stewardship for at-risk species conservation through Citizen Science initiatives, and dissemination of analyses to Fisheries and Oceans Canada, local fishers and First Nations groups.

Working with Recreational Users to Reduce Disturbance to Migratory Shorebirds during High Tide Roosting Periods in the Minas Basin, Nova Scotia

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Migratory shorebird numbers are dropping worldwide, making shorebird conservation a necessity. Although it is obvious that conservation must incorporate human values, it is uncommon to develop strategies with those seen as causing conservation challenges. We identified four sites in the Minas Basin where human-caused disturbance to shorebirds resulted in a decrease in roosting time, as the birds walked or flew away from the disturbance. Resting time, when mudflat feeding grounds are covered by water, is vital to the birds' survival as they continue their migration to South America. Through site audits in August 2016, we identified walkers, anglers, bird watchers, photographers, bathers, swimmers and dog-walkers as the users causing shorebird disturbance. The two sites with the largest flocks, highest number of disturbance events and most interest from local users were chosen as pilot sites for conservation strategies in 2017. Through questionnaires, an online-survey, education and outreach, we worked with users to identify and set aside a dedicated 'Shorebird Resting Beach' at each of the two sites. Through signage, handouts and researcher presence, we asked users to avoid these two beaches from two hours before and after high tide in August 2017. Based on 15 audits at each site, we found that human-caused disturbance was reduced from 2016 at the 'Shorebird Resting Beach' at site one, and remained the same at site two. These data, along with user-interviews, will allow us to assess the effectiveness of our materials and re-implement in August 2018, with the aim of further reducing human-caused disturbance.

Jaya Fahey was awarded the Best Student Paper Presentation at the 12th BoFEP Workshop

Moving towards Sustainable Social-Ecological Systems within the Bay of Fundy: Investigating Opportunities for Integrated Coastal and Marine Management

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Despite being a popular approach globally, operationalizing (i.e., developing, implementing and evaluating) integrated coastal and marine management (ICM), an approach that moves beyond sector-based management, has proven difficult within coastal and marine social-ecological systems (SES) in Canada. The purpose of this study is to determine the role of coastal communities in catalyzing a shift towards sustainable coastal and marine SES in the Bay of Fundy.

Research shows the consideration of coastal community perspectives, in addition to natural science perspectives, strengthens the development of integrated coastal and marine management (ICM) initiatives and increases the likelihood of success; however, there remains a research gap to better

understand how to incorporate coastal community perspectives and capacity into ICM initiatives. The following research objectives will assist in addressing this gap: 1) synthesize past ICM experiences in Atlantic Canada; 2) assess ICM initiatives within the Bay of Fundy; 3) integrate community perspectives on critical barriers and opportunities for ICM within Bay of Fundy; and, 4) develop a suite of recommendations for moving towards positive and desired ICM outcomes in the Bay of Fundy.

This research involves multiple methods and will be completed over the summers of 2018–2019. A systematic review, regional and community-based interviews and participatory planning workshops will be conducted to determine the role of coastal communities in ICM within the Bay of Fundy. As place-based problems often demand place-based solutions, my research aims to enhance the sustainability of coastal SES through a better understanding of how local-regional capacity could complement federal actions through ICM initiatives to enhance operationalization success.

Coastal Communities and Third-Eye Science: Academia, Fisheries and First Nations in the Bay of Fundy, Nova Scotia, Canada

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Fishing weirs have traditionally fostered a unique setting of communal support, food sustenance, and sense of place. The Bramber Weir in Minas Basin, Nova Scotia, is both a commercial weir and a centre for learning about local wildlife and habitats. Originating as a commercial site, the weir has now expanded to include traditional, local and academic knowledge, known as “Third-Eye Science”, hosted under the umbrella of the Marine Institute of Natural and Academic Science (MINAS). The incorporation of traditional knowledge in conservation, research, and management is unique among Fundy weirs, helping maintain the productivity and vitality of ecosystems from which Indigenous communities draw their livelihoods and sense of community.

This film documents the partnership between MINAS, a grassroots organization composed of community stakeholders, including First Nations, dedicated to improving the integration of traditional knowledge into academic-led research, and the Dalhousie University-based Ocean Tracking Network (OTN), a global science platform focused on using acoustic telemetry to track the movements and survival of aquatic species.

Integrating “Third-Eye Science” with acoustic telemetry provides a greater capacity to track biodiversity, and to document the movements and survival of aquatic species in response to anthropogenic stressors. MINAS and the Bramber Weir are leaders in generating community-driven data (citizen science), knowledge mobilization and management actions that address concerns at the ecosystem level, by those who understand it best—the people that live there.

3.3 Tidal Energy

Chair: Anna Redden, Acadia University, Wolfville, NS

Tidal Energy Demonstration in the Minas Passage, Bay of Fundy

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The Fundy Ocean Research Center for Energy ('FORCE') is a non-profit organization that owns and operates Canada's leading research centre for in-stream tidal energy, located in the Minas Passage of the Bay of Fundy. FORCE was established in 2009 to explore if tidal energy can be safe, affordable, and reliable clean energy source for Nova Scotians.

To do this, FORCE acts as a host that allows demonstration devices by providing subsea power cables and connection to the Nova Scotia electrical grid. In 2016, FORCE became home to Canada's first transmission-grid connected tidal energy turbine. In addition, FORCE's Visitor Centre near Parrsboro, Nova Scotia that often serves as the focal point for marine operations while also welcoming more than 4,000 visitors per year—nearly 30,000 in total since the Centre's opening in 2011.

Another key role of FORCE is to act as site steward, providing research and monitoring to better understand the interaction between these devices and the environment. While research has been ongoing at the site since 2008, FORCE's newest monitoring program focuses on marine mammals, fish, lobster, seabirds, and turbine-related sound. Initiated in 2016, the program has completed more than 1,400 days of marine mammal recording days, 264 hours of hydroacoustic fish surveys, 11 days of lobster surveys, four marine sound surveys, 27 seabird surveys, and bi-weekly shoreline observations. While initial results are encouraging, additional and continuous research and monitoring will need to be completed in relation to an operating tidal energy turbine to make conclusions regarding turbine/marine life interactions.

In addition to conducting environmental effects monitoring activities, FORCE also conducts innovative research initiatives through the Fundy Advanced Sensor Technology (FAST) program. FAST consists of a series of onshore and offshore infrastructure that supports innovative research projects that are designed to improve site characterization, environmental monitoring, and marine operations methodologies.

Through these efforts, FORCE has a role to play in supporting informed, evidence-based decisions by regulators, industry, the scientific community, and the public regarding the role in-stream tidal energy could play in Canada's clean energy future.

Environmental Monitoring, Modelling and Forecasting for Instream Tidal Energy Development at the FORCE Test Site

Richard Karsten[1], Alex Hay[2], David Barclay[2], Paul Hill[2], Andrew Gerber[3], Tiger Jeans[3], Joseph Hall[3], Len Zedel[4], Michael J. W. Stokesbury[5], Anna M. Redden[1,5] and Elizabeth **Nagel**[1]

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Canada has in the Bay of Fundy one of the world's richest tidal resources and a world-leading test site for large grid-connected in-stream tidal turbines. However, decisions regarding the development and regulation of the tidal energy industry are hindered by a lack of scientific evidence related to animal/turbine interactions and flow variability. This project, led by Canada's leading tidal energy research team, has received a Canadian Foundation for Innovation (CFI) Innovation Fund award to address knowledge gaps and inform future tidal energy development.

The primary goal of the research planned for 2018-2023 is to address the two challenges facing tidal energy development: the impact of the environment on turbines and the impact of turbines on the environment. Both require a highly integrated suite of field work infrastructure that will quantify the high-flow, dynamic environment of Minas Passage, including measuring flow velocities, mapping the sea bottom, detecting the presence of marine mammals, tracking fish and monitoring the noise generated by turbines. Both challenges also require substantial computing infrastructure to conduct high-resolution numerical simulations and to analyze the large quantities of collected data.

Field projects will utilize mobile equipment to quantify the spatial and temporal variation of flow and turbulence in Minas Passage (Figure 1). Equipment includes drifting buoys and a rigid-inflatable boat outfitted with acoustic devices, drone-borne video and the Jetyak for mapping wakes, and bathymetric sidescan sonar for mapping seabed changes over time. Stationary measurement systems will be deployed to provide complimentary data, including the Stablemoor/ MicroRider to measure the wake field downstream of turbines throughout the tidal cycle.

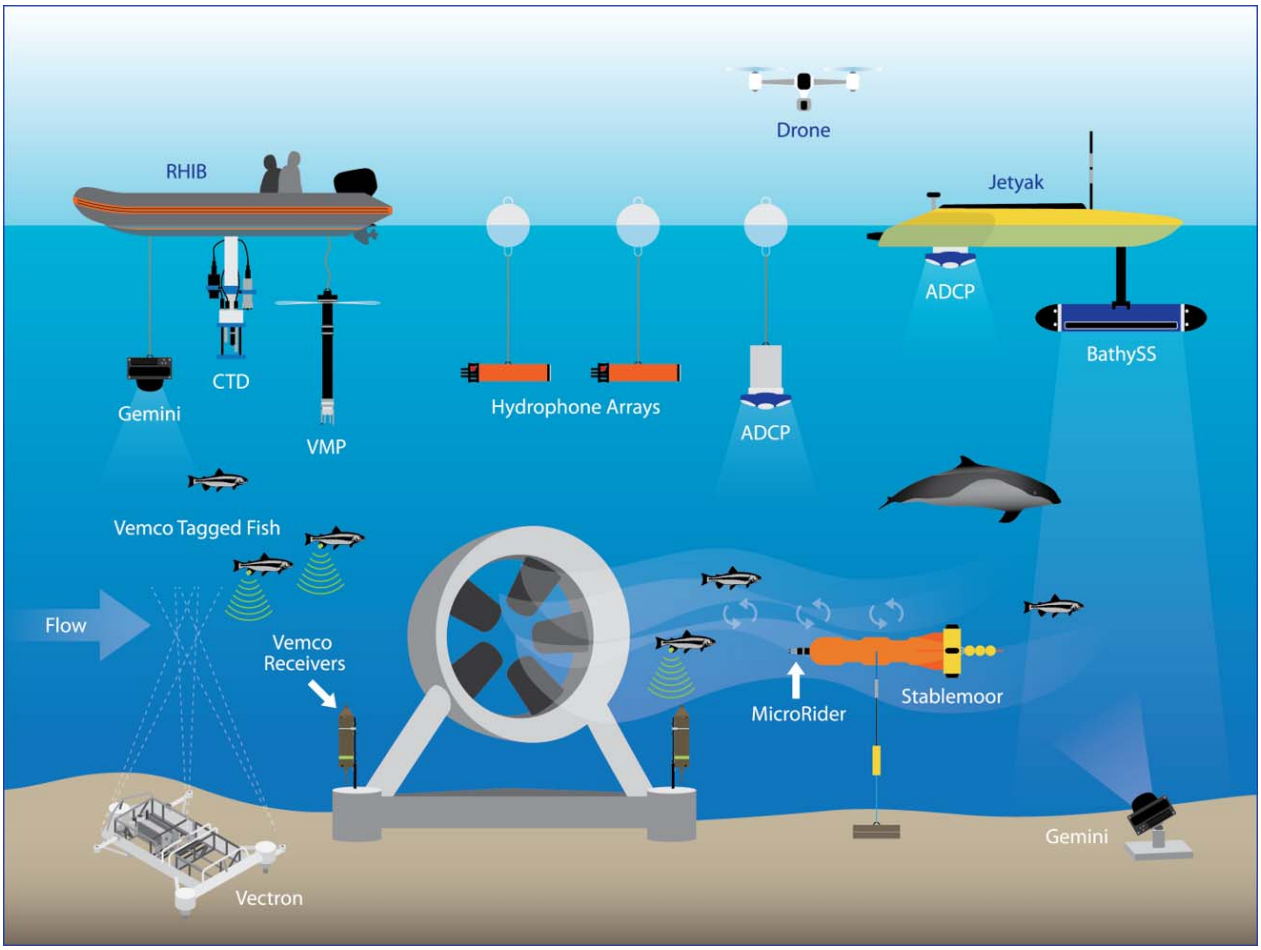
Research projects will also quantify and map the spatial distribution of marine animals and noise at the FORCE test site. State-of-the-art High Residency Vemco fish tags engineered for high flow environments will be used to track Atlantic salmon, alewife, American shad and Atlantic sturgeon in the Minas Passage using an array of acoustic receivers. Tritech Gemini imaging sonar will be deployed to assess the presence, vertical distribution and movement of fish and marine life at the FORCE test site.

Simultaneous sonar datasets will be compared between sites with and without turbines to asses critical near-field (<50 m) turbine effects. These devices will collectively give a detailed picture of how fish and marine mammals interact with turbines. Drifting hydrophone arrays will be used to detect and localize

marine mammals, and to quantify the spatial and spectral distribution of turbine generated noise and propagation. Data from the marine animal tracking projects and turbulence projects will be combined to simulate the impact of commercial scale turbine arrays on marine life.

To complement the field work, high-end computing infrastructure will be used to run simulations of turbines operating in the turbulent flow field. High resolution regional and turbine-level CFD simulations of 3D turbulent flow will be developed, including unsteady forces, to quantify impacts on turbines. Simulations of turbine generated noise will be used to estimate exposure levels and explore design changes to minimize the impact of turbine noise on marine life. Advanced research computing equipment from ACENET will be used to run regional-level simulations of tides and tidal currents. Designs of turbines and environmental impacts will be assessed through extra-high resolution environmental simulations, in order to improve efficiency and reduce turbine impacts. The effects of weather, waves and turbines on tidal currents will be simulated to support the development of real-time forecasts of sea conditions in order to plan field campaigns and tidal turbine deployments.

Figure 1. Integrated use of field work infrastructure to complete project objectives including fish tracking (Vemco tags and receivers, Gemini Imaging Sonar), turbulence measurements (Jetyak, BathySideScan, ADCPs, VMP, CTD, Stablemoor/ MicroRider, Vectron, Drones) and measuring the acoustic environment (hydrophone arrays). Image credit: Jan Sykora.



Using RADAR as a Spatial Mapping Tool for Surface Velocity and Turbulence Detection

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Traditionally the method to estimate spatial variation of surface velocity or turbulence intensity in a region of interest has been done using a combination of Drifters, Acoustic Doppler Current Profilers (ADCPs) and simulated model data. Drifters and ADCPs are used to collect field data at specific points within a region of interest. Field data are then used to validate simulated model data which in turn are used to approximate spatial maps of surface velocity or turbulence intensity for the region of interest. Pioneered by Dr. Paul Bell in the United Kingdom, RADAR can be used extract data across an entire region of interest simultaneously. This is done by collecting RADAR backscatter data from waves in the region then applying post-processing algorithms to extract velocity and turbulence information. The method, limitations, and initial results of applying Dr. Bell's method to the Crown Lease Area (CLA) in the Minas Passage will be presented.

Acoustic Detection of Fish Density and Vertical Distribution and Relationships with Flow Conditions at the FORCE Tidal Energy Test Site

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The effects on fish of marine hydrokinetic (MHK) devices at high flow sites are generally unknown, but of high concern to industry, regulators, the scientific community, fishers and other stakeholders. The goal of this project was to acoustically assess the seasonal vertical distribution of fish at the FORCE site and consider the implications for the likelihood of interactions with the Cape Sharp Tidal MHK device (OpenHydro), which spans 0 to 20 m above the sea floor. Hydroacoustic data were collected with an upward-facing Acoustic Zooplankton and Fish Profiler (AZFP) on a FORCE sensor platform, deployed for one-month intervals at the FORCE site in December 2015 and June 2016. Data were processed to remove unwanted signal, including entrained air near the surface. The data were split into individual tidal stages (ebb or flood) and partitioned into cells 1 m thick, measured upward from the sea floor. The proportion of area backscatter (a proxy for fish density) contributed by each layer of the water column was compared for time periods of interest, for example, day vs. night and ebb tide vs. flood tide, for each season examined. The proportion of backscatter at turbine depth (0 to 20 m above the sea floor) was used to assess seasonal differences in the likelihood of fish encountering the tidal turbine. The correlation between current speed (as determined using an upward-facing Signature 500 ADCP) and fish density (using the AZFP) was also examined for relationships with environmental factors, including tidal and diel stages and water column depth. This ongoing work is contributing to a better understanding of how fish distribution and density relates to hydrodynamic conditions at high-flow sites and is informing predictions of the probability of fish encounters with MHK devices in the Minas Passage.

Quantifying Fish-Turbine Overlap Using High Residency Acoustic Electronic Tagging Technology

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There is a lack of scientific data on the potential effects of instream tidal power development on resident and migratory fishes in the Bay of Fundy. It remains unclear if fishes that occupy Canada's leading tidal energy test site in Minas Passage, will be negatively affected by turbine operation. This void in knowledge exists, in great part, because there has been a lack of technology capable of addressing questions on animal movement and behaviour in areas where tidal current speeds are extreme (often >6m/sec). When predicting possible effects of turbine operation on listed endangered species (i.e., iBOF Atlantic salmon, great white shark) where the loss of one individual may have a negative impact on the population, effects are assessed on the individual level. For plentiful species, it is critical to have an estimate of population or relative abundance, so individual losses can be put into context to predict the fate of the population. In this study, we will use new, high residency acoustic fish tracking technology to attempt to quantify spatial and temporal overlap of one endangered (Atlantic salmon) and three plentiful (alewife, striped bass and Atlantic sturgeon) species with areas chosen for the operation of in-stream tidal turbines. This study will provide information central to predicting overlap of migratory fishes with areas of future tidal power extraction.

Passive Acoustic Drift Surveys of Harbour Porpoise (*Phocoena phocoena)* Presence and Behaviour in the Minas Passage and Adjacent Waters

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Atlantic harbour porpoises, *Phocoena phocoena,* are small, echolocating toothed whales (Suborder Odontoceti) commonly found in the Bay of Fundy, including the Minas Passage. Porpoise click trains used for echolocation were monitored in Minas Channel and Minas Passage using two synchronized icListenHF hydrophones suspended under a drifting spar-buoy. Six 4-6 hour long drifts were completed in June 2017. Data from the two hydrophones showed that porpoises spent about as much time below 15 metres as above; therefore, interactions with tidal turbines at FORCE cannot be dismissed. Porpoise clicks have a frequency of about 130 kHz, duration of about 100 microseconds, and are commonly separated by about 0.1 second when navigating. We observed lower amplitude (~130 kHz) signals of much longer duration with complex modulation that were interspersed between navigating clicks. Such signals may indicate communication, perhaps between mother and calf. Feeding buzzes (high-rate clicking) were observed and had a patterned structure with tightly spaced clusters of 2-4 clicks. Visual porpoise sightings compared well with acoustic detections except near Cape Split where extreme tidal conditions limited visual observations. Future drift studies will focus on expanding the passive acoustic monitoring of porpoises in the Minas Channel and Minas Passage, by using an array of six hydrophones.

This larger array will permit calculation of the precise depth of a porpoise and its distance from the hydrophones. Depth and range make it possible to attribute echolocation clicks to an individual porpoise, allowing determination of the porpoise density close to and away from the turbine. Such results are required for estimating porpoise-turbine encounter rate.

Social Licence and Tidal Energy Development in Nova Scotia, Canada

Caitlin **Peace-Williams** and John Colton

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Nova Scotia is a global example of a region taking advantage of its vast tidal energy resources through tidal energy testing and development. Alongside innovations in tidal energy technology, social economic factors must also be considered, especially the extent to which a social license has been developed. Social licence, which is the ongoing approval or social acceptance of a project in a community, must be developed for communities to support and approve of a project or development. This research explores factors that support the development of social licence in the context of tidal energy in Nova Scotia, Canada. These factors include the importance of public education, the significance of baseline research, an understanding of the technology and its impacts, as well as the role of community and economic development. Interviews with a variety of key stakeholders in tidal energy development provide insight into the role these four factors play in supporting a social license. While these four factors are significant, other factors are critical as well and include legitimacy, credibility, and trust.

3.4 Dykelands and Tidal Wetland Restoration

Chairs: Tony M. Bowron, CBWES Inc., Halifax, NS, and
Danika van Proosdij, Department of Geography and Environmental Studies, Saint Mary's University, Halifax, NS

The Nova Scotia Department of Agriculture's Management Plan for Nova Scotia Dykeland System

Christopher **Ross**

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The Nova Scotia Department of Agriculture (NSDA) is developing a management plan for the Provincial Dykeland System in response to climate change projections and aging infrastructure. A focus on risk assessments, geotechnical considerations and effective management of capital investments will help modernize management of the Dykeland System and marshland it protects. Projects in 2017–2018 include the Fundy Dyke Agricultural Risk Assessment in partnership with New Brunswick under the National Disaster Mitigation Program; Risk Proofing Nova Scotia Agriculture in partnership with the Nova Scotia Federation of Agriculture; and Fundy Agricultural Marshland Flood Maps, also with New Brunswick.

The presentation will demonstrate NSDA's approach for the effective management and protection of agricultural lands, including marshlands and dykelands, by ensuring a continuum of engineering standards, utilizing a participative process providing technical and advisory resources inclusive of local, traditional knowledge and multi-disciplinary teams applying best available evidence-based practices. Under the *Agricultural Marshland Conservation Act*, NSDA is legislated to supervise and manage the agricultural dykeland assets. The infrastructure consists of 240 kilometers of dyke and 246 aboiteaux along the Bay of Fundy, and protects 18,995 hectares of land located on 82 agricultural marshlands. Improved dykeland management is aimed at reducing climate-related hazards and disaster risks such as coastal flooding and erosion in vulnerable regions – Indigenous, costal, remote communities and marshlands areas. The presentation will support stakeholder and technical presentations featured on the Dykeland System as well.

Vulnerability Assessment of Dyke Infrastructure in the Bay of Fundy

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The purpose of this project was to assess the vulnerability and probability of dyke overtopping and/or failure in dykeland areas in Nova Scotia within the Bay of Fundy, to help inform decision making by the Nova Scotia Department of Agriculture. Analysis was performed using updated surveyed dyke elevations, newly released Lidar elevations from the Province, and other attribute data within the Dykeland Decision Support Tool (DDST). Vulnerability to overtopping and/or failure was identified as a function of water depth, crest elevation, exposure, foreshore marsh width, platform elevation and form (ramped versus cliffed), and presence or absence of armouring. Dykes were divided into 25 m segments and attributes assigned per segment using an automated process in ArcGIS 10.5.1. Based on the analysis, dyke tracks were coded into categories of low to high risk and viewed in conjunction with a companion project identifying assets as risk. Historical patterns of erosion and progradation over the last 60 years were quantified for the 1671 individual marsh units fronting 240 km of agricultural dykes in the Province. As seen elsewhere in the region, cyclical patterns of erosion and progradation were observed within each Basin however the impacts of human action on this process (e.g., armouring, engineering, dredging) were evident. Ecomorphodynamic principles were then applied to identify areas of foreshore marsh that had the greatest or least likelihood of continuing to provide natural forms of coastal defense in the future, and time period over which this would occur.

Truro Flood Risk Study: Looking for Sustainable Flood Protection

Alexander **Wilson**[1], Vincent Leys[1], Rick Giffin[1], Gordon Smith, Andrew Gates[1], Justin Forbes[1], Victoria Fernandez[1], Jeff Marvin[1], Maggie Burke[1], Archie Thibault[1] and Danika van Proosdij[2]

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Truro is notorious for being subject to the most frequent flood events of any developed area in Atlantic Canada. All previous assessments had pointed to the difficulty in resolving the complex interaction between the highest tides in the world, very large runoff flows, river sedimentation and recurring ice jams. Millbrook First Nation, the County of Colchester and the Town of Truro leveraged provincial funding to commission this ambitious study and attempt to develop clear answers based on sound science.

The Truro Flood Study is the most comprehensive flood study ever undertaken in Atlantic Canada. One of its main goals was to incorporate the latest computer techniques that built upon the most detailed information recently available (Lidar mapping for the entire watershed, seasonal sediment characterization, bathymetric surveys and velocity profiling). One-D, 2D and 3D hydrodynamic and ice jam models were used to study the relative influence of extreme rainfall, macrotidal conditions, sedimentation in the estuary and ice jams, which all play a role in creating high risks of flooding in the area. Climate change impacts were also studied, a clear departure from previous flood study results.

Striking a Balance: Application of Coastal Habitat Restoration for Climate Change Adaptation

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The conservation, restoration and use of vegetated coastal habitats in eco-engineering solutions for coastal protection are increasingly being accepted as providing a promising strategy, delivering significant capacity for climate change mitigation and adaption. Coastal habitats provide a range of climate change adaptation and ecosystem services including erosion protection, stormwater retention and filtration, land and habitat creation and carbon storage. Globally, the practice of re-introducing, where feasible, tidal flow to former dykelands and the restoration of tidal wetland habitat, has been identified as a viable adaptation method to current and future risks associated with climate change. In

addition, there is increasing recognition of the potential of restored salt marshes to provide 'blue carbon' benefits. With limited resources available, guidance is required to determine which dykes to remove that will optimize ecosystem services while providing climate change adaptation benefits, minimize economic costs yet still maintain fertile agricultural land and social, cultural and historic activities. Pending and on-going managed realignment projects in Nova Scotia (i.e., Truro-Onslow realignment and tidal wetland restoration project) will be used as a framework for discussion on challenges and opportunities presented for coastal habitat restoration for climate change adaptation.

Building on Ten Years of Experience to Design the Truro-Onslow Dyke Realignment and Tidal Wetland Restoration Project

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Globally, the practice of re-introducing tidal flow, where feasible, to former dykelands and restoring tidal wetland habitat, has been identified as a viable adaptation method to current and future risks associated with climate change. Located at the confluence of the North and Salmon Rivers near the town of Truro, Nova Scotia, the Onslow North River Marshland provides an important opportunity to demonstrate the environmental and social benefits of a large-scale strategic dyke realignment project, as well as the benefits of a multidisciplinary and multi-stakeholder approach to tidal wetland restoration. Carried out in collaboration with the Nova Scotia Department of Agriculture (NSDA), Nova Scotia Transportation and Infrastructure Renewal, and the Onslow North River Marsh Body, this project included the realignment of the existing dyke, the dyke decommissioning and hybrid tidal creek network design, and the hydrodynamic modeling of restoration scenarios. This presentation will focus on the process and technical aspects of the project design and the expected outcomes of the realignment and restoration project, which include the restoration of ~80 ha of tidal wetland habitat, reduced flood risk, and reduced maintenance costs for NSDA.

The Impact of Flood and Erosion Prevention Structures and Strategies on Saltmarsh Development in the Cobequid Bay, Nova Scotia

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Flood and erosion prevention structures and strategies (e.g., dykes, borrow pits) are often implemented in anthropogenically modified coastal regions to protect against coastal hazards. If saltmarshes are to be incorporated into a coastal management plan as a source of coastal defence it is paramount to understand how ecomorphodynamic feedbacks triggered by implementing flood prevention structures and strategies can impact saltmarshes. This study examines how these structures in combination with natural drivers have precipitated changes in foreshore saltmarsh erosion and progradation rates over varying spatial scales in the hypertidal Cobequid Bay, during the past 80 years. Foreshore change rates were obtained using a geographical information system (GIS), as well as imagery and digital surface models (DSMs) derived from an unmanned aerial vehicle (UAV). Furthermore, UAV DSMs were used to determine short-term sediment budgets in saltmarsh borrow pits. Natural cyclical foreshore change rates were observed in the Cobequid Bay, but are often augmented by the presence of anthropogenic structures. Erosion and progradation rates in individual transects have been observed to be as much as -14.9m/year and 20.1 m/year, respectively. Furthermore, results suggest that under specific environmental conditions some structures work in tandem with saltmarshes to protect the upland by precipitating ecomorphodynamic feedbacks that promote saltmarsh progradation. Conversely, other structures can exacerbate natural cycles of erosion, locally. Borrow pit studies reveal that although local suspended sediment concentrations, which can vary from 50mg/l to 50000mg/l, play an integral role in pit sedimentation, channel geometry design may play an equally important role in governing infill rates.

Dynamics of Focal Plant Patches during a Salt Marsh Restoration in the Upper Bay of Fundy from 2011–2017

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Salt marshes are vital, highly productive ecosystems, characterized by halophytic vascular plants that have successfully colonized soft sediments in the high intertidal zone. In recent years, there has been much interest in restoring salt marshes. Since 2011, in a salt marsh restoration project in Aulac, New Brunswick, we monitored vegetation dynamics in "patches" in two previously diked terrestrial cells (i.e., sites being restored), as well as in two adjacent reference salt marshes. Specifically, we quantified stem density and status (live, dead, flowering) and plant height, as well as conducted year-specific investigations into soil salinity, root biomass, and "patch" connectivity. After the old dikes were breached, *Spartina pectinata* (freshwater cordgrass), which was present on-site prior to breaching, survived and spread from 2011 to 2013, although it showed stunted growth. From 2013 to 2015, we observed the decline and eventual disappearance of *S. pectinata* from the restoration sites. The primary

ecosystem engineer of salt marshes, *Spartina alterniflora* (saltwater cordgrass), appeared in 2012, displayed the tall form phenotype, vigorously spread vegetatively (by rhizomes), and then starting in 2014 spread sexually (by seeds), until it formed a dense cover throughout each restoration site. Upon comparing established and seedling "patches" of *S. alterniflora*, we found that seedlings take 2 years to become established and start reproducing vegetatively and to flower. Currently, in addition to growing along the dikes, there are two "patches" of *Spartina patens* (salt marsh hay) located within one of the restoration site, forecasting the expected future change in plant community. We plan to continue to monitor the "patch" dynamics of plants in Aulac and use our detailed observations to model the colonization and spread of salt marsh plants during restoration in the upper Bay of Fundy.

Community Dynamics in a Salt Marsh Restoration Project in the Upper Bay of Fundy: Seven Years Later

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Salt marshes are highly productive ecosystems characterized by salt tolerant plants that have colonized soft sediment areas in the high intertidal zone. Due to the high fertility of salt marsh soil, many salt marshes were converted to agricultural land over the past three centuries. Given the many ecosystem services we now know are provided by salt marshes, there is considerable interest in reverting diked farmland back to salt marsh. Managed realignment, where a new dike is built upland and a salt marsh is encouraged to develop in front of it, is currently a popular coastal management strategy, and is being used and tested in our project. Our salt marsh restoration project started in 2009–2010 in Aulac, NB; two adjacent cells of farmland were opened to sea water by manually breaching the old dikes. Each summer, we revisit and quantify the emergent plant and invertebrate communities of these restoration sites and 2 adjacent natural sites (i.e., reference salt marshes). The restoration is currently at a critical phase where (i) the salt marsh foundational grass species, *Spartina alterniflora*, has established itself and spread throughout the restoration sites and (ii) the old dikes have eroded away leaving the young marshes exposed to the full force of erosion. Very encouragingly, the restoration salt marshes are continuing to accumulate sediment at high rates, possibly due to increased plant cover. This study provides a valuable opportunity to study the long term restoration dynamics of salt marshes in the upper Bay of Fundy.

Living Shorelines in Atlantic Canada: Effectiveness of Natural Bank Protection

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Living shorelines encompass a broad spectrum of nature-based techniques used to manage coastal challenges such as erosion, flooding, habitat loss, and water quality. Living shorelines are an alternative

to hard shoreline protection structures, like bulkheads and stone armouring. These alternatives are gaining increasing attention as the negative effects of shoreline hardening, such as loss of beaches, decreased accessibility, increasing costs and degradation of nearshore habitat, are becoming more prevalent as the amount of hardened shorelines, and our understanding of the impacts, steadily increases. Globally, living shoreline research is showing promising results for erosion reduction, storm protection, and habitat restoration in a wide variety of coastal environments. In Atlantic Canada, awareness and popularity of living shoreline concepts has been growing, primarily among coastal landowners. The research presented here investigated the effectiveness of three, locally developed techniques that are currently being used in NS and PEI to reduce erosion on coastal banks. The combination of mulching with hay, weaving brush, and planting native species has been shown to be effective in reducing erosion and encouraging revegetation on many of the coastal properties where it's been tested. The results of this recent study confirm that erosion rates from sub aerial processes and upland factors can be significantly reduced using this combination of techniques. This represents the first experimental investigation into this kind of nature-based erosion management in Nova Scotia. The positive results will hopefully lead to an increased awareness and application of living shoreline concepts in coastal management in Atlantic Canada.

Modeling Present-Day and Future High Water Lines with Lidar, Surveyed Dykes, and Modeled Water Crossings, and its Impact on Dykelands

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French settlers began constructing dykelands in Nova Scotia in the 18th century to expand on available areas to grow hay. Today, the responsibility of maintaining the dyke infrastructure lies with the provincial government with landowners responsible for the land itself. The dykes and the land are susceptible to damage over time but changing conditions necessitate a review of the present High Water Line (HWL) for every dykeland in Nova Scotia. As part of the National Disaster Mitigation Program, we are investigating boundaries (demarcated since the 1950's) of existing dykelands in Nova Scotia that are designated to a Marsh Body. Using the present day HWL elevation, existing boundaries will be compared to boundaries delineated with lidar digital elevation models and surveyed elevations. We have developed a procedure to model concealed water crossings to connect flood zones that would otherwise appear isolated. The maps from this project will show cases where the dykes and/or surrounding upland is below the present-day HWL, and can be used to assist managers to assess risk and make better informed decisions on dyke elevation, aboiteau size, etc.. These maps will also be important for owners of infrastructure (e.g., buildings and roads) that would be affected by flooding. In addition, future implications of sea level rise sets in motion conditions that will require further consideration of adjusting Marsh Body boundaries in most cases. We have applied the same methodology to show future HWLs, while highlighting the risk to infrastructure if steps are not taken to prepare for changing conditions.

Shoreline Management on the Bay of Fundy: Past and Future

Donald **Killorn**

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Many coastal property owners in New Brunswick are concerned about property loss or damage due to erosion and the prevailing response to this threat has been armoring of shorelines with hard, engineered structures (e.g., bulkheads, revetments, seawalls). While these structures provide varying degrees of protection to upland property, they have been shown to have numerous adverse effects on the habitat and biological communities that surround them.

Where appropriate, a "softer" approach to stabilizing shorelines is needed. One that mimics natural shorelines, can adapt to a changing climate, and improves the overall health of coastal ecosystems while protecting property.

In 2017, the Bay of Fundy Ecosystem Partnership received funding from the New Brunswick Environmental Trust Fund to explore the concept of living shorelines. This presentation will discuss the concept of living shorelines, design considerations, and next steps for implementing living shoreline techniques on the Bay of Fundy. The presentation will also discuss the Talking Circle held in St. Andrew's that focused on the scientific, cultural and historical relationships between middens and the Indigenous peoples of Passamaquoddy Bay.

How Can Public Discourses Identified Using Q-Methodology Help Inform the Management of Bay of Fundy Dykelands Under Climate Change?

Kate **Sherren**

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The Acadian dykelands of Nova Scotia represent an opportunity to explore the social and governance limits to coastal climate adaptation in cultural landscapes. A representative online Q-methodology survey of 183 adult residents of Nova Scotia was conducted in the spring of 2015. Respondents sorted 34 statements along a normal distribution ranging from agree to disagree, about whether they prefer dykeland maintenance or wetland restoration, and under what governance arrangements. The dominant discourse was local, female and strongly pro-dykeland, indicating the some likelihood of local resistance to dykeland removal for cultural, recreational as well as flood control reasons. The second factor was supportive of wetland restoration for reasons of efficiency, not wetland affinity, and was characterized by those in positions of management power. The two minority viewpoints were less informed about dykelands, characteristic of outsiders, and more concerned with governance. Results also suggest that more education is needed about the challenges and options facing dykelands and proposals should emphasize flood mitigation over cost-saving. Cultural associations and status quo bias are clearly barriers to adaptation planning. Theoretical development since this work on the concept of climax thinking offers several potential leverage points for framing landscape change in such contexts, but requires additional testing.

3.5 Monitoring and Contaminants

***Chair*: Jack Fife, Fisheries and Oceans Canada, St. Andrews, NB**

Mussels and Sediment as Monitoring Tools for Contaminants: Which to Use When?

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For decades, sediments and mussels have been used to assess the ecological and human health risks associated with concentrations of bioavailable organic and metal contaminants in a variety of coastal-wide and localized monitoring programs. Mussels (*Mytilus edulis*) bioaccumulate organic and metal contaminants from the water and sediment, whereas sediments serve as repositories for particle-active contaminants. In the Gulf of Maine (GOM), monitoring coastal contamination in both sediments and mussels has been done through area-wide monitoring programs such as Mussel Watch (NOAA) and the National Coastal Assessment (EPA) on the U.S. side. Gulfwatch, a joint Canadian–U.S. program, monitors contaminants in mussels at several sites to identify contaminant “hot spots” within the whole GOM. The need for sediment data from the Bay of Fundy prompted sediment collection in 2015 under the aegis of the EcoSystem Indicator Partnership from Gulfwatch stations along the Bay of Fundy coastline. Sediments were analyzed for a suite of organic and metal analytes, and bulk organic carbon. We compare mussel and sediment concentrations at several different sites in the GOM utilizing data from 2005–2015 from the above programs. Preliminary results show little correspondence between sediment and tissue contaminant concentrations of mussels collected in prior years at these same sites. Potential causes of this disconnect include space-time and geomorphology differences. We explore scenarios where one or the other matrix is better suited for describing environmental health. The factors that affect the utility of mussels vs. sediments as monitoring tools include spatial and temporal influences and the dynamics of their respective environments.

Cobble-Filled Bio-Collectors: a Tool for Detecting Changes in Biodiversity in a Difficult-to-Sample Habitat in the Bay of Fundy

Heather L. **Hunt**[1], Marie-Josée Maltais, Brent Wilson, Krystal Woodard, Curtis Forbes and Rémy Rochette

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In the Outer Bay of Fundy, shallow cobble habitat harbours a diversity of species, and serves a nursery function for commercially important species such as the American lobster. However, conventional methods do not sample this habitat effectively. Cobble-filled bio-collectors were developed to monitor settlement of American lobster in cobble habitat, but are colonized by a wide variety of invertebrates and fishes. We have a 10-year dataset of decapod crustacean and fish abundance (and for some years, data for all invertebrates; >500 species detected) from bio-collectors deployed in the southwest Bay of Fundy, which is considered a biodiversity hotspot and is among the fastest warming regions globally. We will present multivariate analyses of decapod and fish assemblages, which suggest that overall assemblages have remained similar over the last decade. We will also examine trends in individual species over this time period. Our dataset provides the first record (2012) of juvenile cunner *Tautogolabrus adspersus* in this region and recent research motivated by this finding suggests the species is undergoing range expansion driven by increasing water temperature during embryo development. Our dataset demonstrates that cobble-filled bio-collectors are a useful tool to detect changes in biodiversity in shallow cobble habitat in response to anthropogenic impacts.

Microplastic Concentrations in the Intertidal Sediment and Benthic Organisms in the Lower Bay of Fundy, Southwestern New Brunswick

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Microplastics are a contaminant of emerging concern that originate from the breakdown of plastic debris (consumer and industrial) which is regularly introduced into the marine environment. As plastics breakdown, they are distributed throughout the marine environment and can accumulate in marine sediments where they can release potentially hazardous additives (i.e., bisphenol A, phthalates). Microplastics can also adsorb previously existing persistent organic pollutants which can bioaccumulate through the marine food web. In southwestern New Brunswick Bay of Fundy region, rates of plastic degradation may be influenced by extreme tides and long sun exposure during low tide, potentially leading to increased microplastic production (<5 mm) in intertidal sediments. Microplastic accumulation can increase marine wildlife mortality and reduce availability of suitable coastal habitat. This study quantifies regional microplastic distribution in intertidal marine sediments and, through the assessment of concentrations of microplastics in bivalve tissues, examines the potential impact of microplastics on benthic communities. Biological uptake is assessed using two species of bivalve, *Mya arenaria* (soft-shelled clam, filter feeder) and *Limecola balthica* (macoma clam, deposit/sediment feeder). Microplastic concentrations in sediments and bivalves are determined through density separation of microplastics followed by microscopic quantification. Data analysis will assess the relationship between concentrations in sediment and in sediment-dwelling clams.

Metadata for Bay of Fundy Long-term Hydrographic Monitoring Stations

Frederick J. **(Jack) Fife**, Frederick H. Page and Blythe D. Chang

Fisheries and Oceans Canada, St. Andrews Biological Station, St. Andrews, NB (jack.fife@dfo-mpo.gc.ca)

Stations Prince 5 and Prince 6 are located in the Bay of Fundy and in the St. Croix River estuary respectively. Seawater temperature at the surface and at different depths down to near bottom has been measured and recorded at regular intervals at these two monitoring stations for more than 100 years by St. Andrews Biological Station staff.

The precision of these data must be determined before use in climate studies. There were many different instruments used over the years. We now have to verify that measuring devices used have been properly catalogued and calibrated. This information must be included with the data as metadata. The aim is to convey to future users "all details about study context, data collection, quality control and assurance as well as analytical procedures from the beginning of a research project and then including this descriptive information in the metadata" (Kervin et al. 2013). This metadata file is being prepared following the *Ecological Archives* metadata content standard which is based on the format described in Michener et al. (1997). "Information about sampling designs, research methods, and identification of project personnel is central to interpreting and using data."

3.6 Oceans Protection Plan & Marine Protected Areas

Chair: Heather Breeze, Fisheries and Oceans Canada, Dartmouth, NS

Oceans Protection Plan: Overview and Introduction

Phoebe **Miles**

Community Engagement and Partnerships, Transport Canada, Ottawa, ON (phoebe.miles@tc.gc.ca)

The Oceans Protection Plan highlights the Government of Canada's new direction on marine safety and shipping. The Government is investing $1.5 billion in the Oceans Protection Plan, a national strategy to create a world-leading marine safety system that provides economic opportunities for Canadians today, while protecting coastlines for future generations. It will focus on four priority areas:

- A world-leading marine safety system, which will improve how we prevent and respond to marine incidents;
- Protecting the marine environment by preserving and restoring marine ecosystems;
- Strengthening Indigenous partnerships; and
- Investing in science and local knowledge to produce a stronger evidence base.

The implementation of the Oceans Protection Plan will involve a whole-of-government strategy led by four federal departments. The Oceans Protection Plan places a strong emphasis on working collaboratively with marine stakeholders, along with forming new partnerships with Indigenous groups and other coastal communities.

The session will include an overview presentation of the Oceans Protection Plan led by Transport Canada with a focus on engagement and collaboration activities in the Atlantic region.

Piloting a Risk-based Response Planning Approach

Angela **Sangster**

Canadian Coast Guard, NB

In 2013, Transport Canada's Tanker Safety Expert Panel made a number of recommendations aimed at strengthening Canada's Marine Oil Spill Preparedness and Response Regime including the implementation of a regional, risk-based approach to environmental response planning for oil spills. In response to these recommendations, the Area Response Planning initiative was launched in 2014. The Area Response Planning pilot projects concluded in summer 2017. Lessons learned from the Area Response Planning initiative will inform the development of the Regional Response Planning pilot project for northern British Columbia, an Oceans Protection Plan initiative that was launched in 2017. The Regional Response Planning pilot project in northern B.C. will develop a risk-based approach to environmental response preparedness that is tailored to the unique conditions, risks and sensitivities specific to the area.

The scope of the Regional Response Planning is broader than that of the previous Area Response Planning initiative. It will look at additional hazards and sources of marine pollution, including vessels of all sizes; involve greater collaboration and engagement with Indigenous Peoples and coastal communities; and aim to be better integrated with existing marine planning and management mechanisms including planning frameworks at international, national, provincial, regional and local levels.

As planning efforts get underway in northern British Columbia, work done as part of the Regional Response Planning pilot as well as the Area Response Planning will be reviewed and, where applicable, will inform the development of a more collaborative environmental response planning approach for marine spills in Canada.

Fisheries and Oceans Canada's Renewed Marine Environmental Quality Program

Heather **Breeze**

Oceans and Coastal Management Division, Fisheries and Oceans Canada, Dartmouth, NS (heather.breeze@dfo-mpo.gc.ca)

Under Canada's Oceans Protection Plan, Fisheries and Oceans Canada received funding to reinvigorate its marine environmental quality (MEQ) program. The aim is to increase understanding of and address pressing issues affecting the quality of the marine environment. In related initiatives, DFO is also increasing its work on marine stressors, cumulative effects and baseline data. Over the next few years, the MEQ program will focus on issues affecting marine mammals, including noise. While marine mammals and noise is the short-term focus, the long-term goal is to create a comprehensive environmental quality program that provides the necessary information as well as the regulatory and

non-regulatory tools to maintain all aspects of healthy marine, coastal and estuarine ecosystems. As responsibilities for managing activities in the marine environment are shared, maintaining healthy ecosystems cannot solely be accomplished by DFO efforts. To be successful, the MEQ program seeks to collaborate with other regulators, industry, Indigenous groups, non-government organizations and community groups. The presentation will highlight efforts underway to better understand the soundscape in the Bay of Fundy-Scotian Shelf bioregion, as well as other activities related to key MEQ issues.

Oceans Protection Plan: Cumulative Effects of Marine Shipping

Paula **Doucette**

Transport Canada, Vancouver, BC (paula.doucette@tc.gc.ca)

As part of the Oceans Protection Plan, the Government of Canada will establish a shared approach to better understand coastal ecosystems and the potential effects of regional marine vessel activity on the environment. Transport Canada's Cumulative Effects of Marine Shipping Initiative seeks to create a cumulative effects assessment framework that would focus on 6 coastal sites across Canada including an area within the Bay of Fundy. Local communities, stakeholders and Indigenous Nations will be engaged to determine key concerns and help collect baseline information that can be used to inform assessments of the cumulative effects of marine shipping framework and identify specific mitigation tools that can be applied to existing and future vessel movements.

This presentation will provide an overview of the cumulative effects of marine shipping initiative, engagement and collaboration activities, timelines of the initiative, desired outcomes, and next steps.

Strengthening Relationships through Coastal Environmental Baseline Data Collection: A Case Study in the Port of Saint John, New Brunswick

Graham **Bartlett**[1], Rachel Long[2], Claire Mussells[3], Stacey Paul[4] and Mike Sullivan[5]

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Ecosystem characterization and evidence-based decision making are crucial to the effective management and preservation of marine ecosystems in Canada's busiest and most industrial ports. The collection of comprehensive baseline data, will provide a snapshot in time, and allow for better detect of changes in the environment. Over the next four years, the Coastal Environmental Baseline program, an initiative under Canada's Ocean Protection Plan, will be piloted in six sites across Canada, the Port of Saint John being one of the pilots. The Port of Saint John is located in the Bay of Fundy and is home to industries such as fisheries, aquaculture, oil and gas, mining and ecotourism. Fisheries and Oceans Canada is working with local Indigenous and stakeholder groups to collaboratively identify key ecosystem components and study site boundaries; compile current and historical environmental

datasets to identify outstanding data needs; prioritize, plan and carry out data collection; as well as data management and visualization. The datasets will be available to participating groups as well as Fisheries and Oceans Canada and other federal departments to inform management decisions in areas such as fisheries management, species at risk, environmental impact assessments and Transport Canada's Cumulative Effects of Shipping program. This program sets out to strengthen relationships with local Indigenous and stakeholder groups by helping to increase local capacity to collect ecological, social and culturally important ecosystem indicators to better reflect their needs in decision making and to allow for changes in the environment to be better detected over time.

Marine Protected Area Network Development in the Scotian Shelf Bioregion: Progress to Date

Elise **Will**[1], Marty King, Tanya Koropatnick, Maxine Westhead, Derek Fenton, and Gary Pardy

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In the past two years, Canada has significantly increased its percentage of marine protection from less than 1% to over 7% nationally. This has largely been driven by Canada's commitment to achieving Aichi Target 11 (under the Convention on Biological Diversity) of 10% protection by the year 2020. An important part of this process has been the development of marine protected area (MPA) network plans within five of Canada's 13 aquatic bioregions. This work has been ongoing in the Scotian Shelf Bioregion, which includes the Bay of Fundy, Gulf of Maine, the Scotian Shelf, and deeper waters of the abyssal plain. An MPA network plan for the Scotian Shelf Bioregion will ultimately guide the establishment of new MPAs in the region over the long term.

As an intermediate step, a draft MPA network design for the Scotian Shelf Bioregion will soon be released for consultation. A brief overview of the steps taken to develop the draft MPA network design will be presented. This will include an overview of the key ecological and socioeconomic data inputs, the method for selecting candidate sites in both the offshore and along the coast/in the Bay of Fundy, and the approach used to minimize potential socioeconomic impacts. Finally, more information will be provided on the next steps to reach a final MPA network plan for the Scotian Shelf Bioregion.

4. Poster Abstracts

4.1 Information Use at the Science-Policy Interface in Decision-Making in the Bay of Fundy Region

Sharing Victories: Enablers and Barriers to Collaborative Relationships within the Conservation Sector

Rachael **Cadman**[1], Bertrum H. MacDonald[2] and Suzuette S. Soomai[2]

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At the 10th Conference of Parties to the UN Convention on Biological Diversity in 2010, Canada committed to protecting 10% of Canada's territorial ocean by the year 2020. When the federal government recommitted to that goal in 2015, it also set an interim goal of protecting 5% by the end of 2017. Shortly after the election in 2015, the government convened a meeting for Environmental Non-Government Organizations (eNGOs) to enlist their help in achieving these targets. By engaging with eNGOs to solicit their assistance with the 2020 targets, the federal government encouraged their active participation in the decision-making process. Since 2015, eNGOs have been engaged in gathering and distilling information to advise policy makers on the creation of marine protected areas (MPAs) in Canada's coastal and marine environment.

In this more inclusive environment, many Canadian eNGOs have chosen to work collaboratively to promote a unified message. A case study of two eNGOs: World Wildlife Fund Canada (WWF), and the Ecology Action Centre (EAC), examined the nature of those formal and informal collaborative relationships, and the enablers and barriers to successful partnerships between organizations. This poster presents key findings from the study focused on the efforts of WWF and EAC on the design and implementation of three MPAs and makes recommendations for effective collaborative work within the Atlantic eNGO community.

Rachel Cadman was awarded the Best Student Poster at the 12th BoFEP Workshop

Global Resource, Local Needs: A Case Study of the Use of the International Aquatic Sciences and Fisheries Abstracts Database

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A significant hallmark of today's society is the large quantity of scientific information about marine environments available to researchers and decision-makers in a wide diversity of formats. Although much information is easily accessible, sizeable volumes may be unknown or limited in access despite their benefit for stakeholder communities. The Aquatic Sciences and Fisheries Abstracts (ASFA) database

has been a global resource since 1971 on the science, technology, and management of marine, brackish water, and freshwater environments, and is an access point for a large number of grey literature publications. Currently, ASFA contains over two million records, of which over 3,000 relate to the Bay of Fundy.

Due to the rapidly changing information landscape today, the future of ASFA in its present form is being reconsidered. Does an abstracting and indexing service have a place in present day marine research and ocean and coastal management? Does ASFA meet the information needs of its potential users or are alternatives available that are equally or better-suited to users? This poster will report on research, pursued in collaboration with the Food and Agriculture Organization of the UN, to determine how ASFA is currently accessed and used. This poster will show how a resource with a global reach relates to the Bay of Fundy and outline the impact changes in the service may have for researchers and others in the region.

The Important Role of Technical Working Groups in Evidence-Based Decision-Making for Marine Fisheries Management

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The use of scientific information for evidence-based decision-making is a critical component of integrated coastal and ocean management. However, ensuring that the "right" information is available for addressing these issues can be a challenge as this information often resides in different organizations with different management mandates. Consequently, marine management organizations addressing complex issues have utilized a range of approaches, including technical advisory committees and working groups, to promote the development of robust solutions and recommendations for integrated management. This poster presents the results of a case study that examined the role of technical working groups in fisheries management in Belize. These working groups include representatives of government and non-governmental organizations, academic institutions, and the fisheries sector. Based on interviews of members of three working groups and decision-makers in the Belize Fisheries Department, information production and communication processes, and how information products are used were determined. Characteristics of the science-policy interface in fisheries management, including common enablers and barriers related to knowledge exchange were identified. Technical working groups play an extremely important role as boundary agents that bridge the communication of information between scientific and policy-making groups. Criteria for evaluating the effectiveness of working group strategies in facilitating evidence-based decision-making were developed based on the identified enablers to production, communication, and use of information. The results of this study can inform organizations using similar working group strategies to enhance stakeholder collaboration and to produce credible, relevant, and salient information for integrated coastal and ocean management in the Bay of Fundy region.

Examining Socioecological Ocean Connections in a Coastal Community: Implications for Local Policy and Science Communication

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Engaging the public in the development of policy is recognized as an integral element of coastal governance today. The coast is a very complex socioecological setting in which a variety of interests often compete for resources and space. To effectively manage shared coastal areas, decision-makers must first understand how coastal residents value the coastal zone. A 2017 survey conducted in Falmouth, Massachusetts uncovered perceived "connections" expressed by coastal residents for the marine environment and identified their preferred coastal policy adaptations. The results show 1) uncertainty related to the safety of the community regarding flood risk, 2) a strong belief in the protection of wetland and coastal habitats, 3) a call to limit human-made coastal structures and restore natural barriers, and 4) a desire for interaction between local scientists and citizens, and more accessible ocean science. This poster provides recommendations for policymakers in coastal communities to incorporate public perceptions and community input into communication and planning efforts.

Characteristics of the Science-Policy Interface: Scientific Information Use in Coastal and Ocean Decision-Making

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Understanding how scientific information is communicated and used at the science-policy interface is fundamental for strengthening policy- and decision-making processes designed to provide solutions for ongoing serious coastal and ocean problems. For over a decade, the interdisciplinary Environmental Information: Use and Influence research program at Dalhousie University has been conducting research, in collaboration with national, regional, and international governmental and non-governmental organizations, that provides empirical evidence to characterize the interface. Drawing on the results of this research, this poster describes major enablers and barriers that affect the update of scientific information in decision-making. Case studies on the use of state of the environment reports, technical assessments, and coastal atlases; studies on communication in multi-sector networks; and studies on decision-making processes within governmental organizations identified the enablers and barriers. A suite of quantitative and qualitative methods (e.g., citation analysis; content and discourse analysis; interviews of researchers, decision makers and other stakeholders; observations of meetings at local, regional, and international levels; and network analysis) were used to build an understanding of the interactions at the science-policy interface. This research shows that multi-stakeholder partnerships

involving government and non-governmental organizations, academic institutions, industry, and the public facilitate the production of credible, relevant, and legitimate information for decision-making. Furthermore, the uptake of such "useable" information is often influenced by organizational processes, the bridging roles of particular actors, and the formats of information products. Nonetheless, awareness remains a major barrier for effective communication and use of information in coastal and ocean management. This understanding of the science-policy interface can guide individuals and groups in the Bay of Fundy region to pursue appropriate roles in policy-making processes, thereby promoting good coastal and ocean governance.

4.2 Dykelands and Tidal Wetlands Restoration

Looking Back over Twelve+ Years of Tidal Wetland Restoration Projects in Nova Scotia, Canada

Tony M. **Bowron**[1], Jennie M. Graham[1], Danika van Proosdij[2], Jeremy Lundholm[3], Nancy C. Neatt[1] and Robert Pett[4]

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Tidal wetlands play a key role in our environment, particularly in the face of the increasing risks associated with climate change and rising sea levels. Conservative estimates for Nova Scotia (NS) put the loss of tidal wetland habitat at greater than 50% province wide, and that number jumps to approximately 80% for the Bay of Fundy, mostly associated with dyking and conversion to agricultural land. Although these activities are of historical and social significance, it is now recognized that the large scale loss of habitat, species and primary productivity that has resulted from the construction of dykes, modern tidal barriers (causeways), and coastal development have had considerable adverse ecological impacts. Since 2005, efforts have been made to mitigate the loss of tidal wetland habitat in Nova Scotia. During that time over a dozen tidal wetland projects, complete with comprehensive long-term ecological monitoring programs have been undertaken. These projects have ranged from replacing tidally restrictive culverts (i.e., Cheverie Creek), to the breaching of agricultural or impoundment dykes (i.e., Walton River) and allowing for passive restoration of wetland species and function, to the inclusion of more active restoration efforts such as the design and construction of tidal channels and pannes (i.e., St. Croix). This poster will provide a look back over twelve years of tidal wetland restoration projects in NS highlighting successes in the field, advancements in restoration design, lessons learned, and a look forward to what the next decade may hold for tidal wetland restoration in the region.

High Resolution, Low-Altitude Aerial Photography for Habitat Restoration, Monitoring and Mapping

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One of the technologies that we have used over the past eight years to design and monitor coastal habitat restoration projects has been low-altitude aerial photography. For example, our use of helium balloon and drone-based camera systems to produce high resolution digital imagery which enables us to track changes in landscape level morphological conditions and vegetative re-colonization at a fraction of the time, effort and cost of traditional monitoring methods or aerial photography. The use of this technology continues to enhance our ability monitor habitat conditions, is less intrusive and enables us to produce a high quality product at an affordable rate. As the technology evolves, so does the range of scientific and management applications in which it is making a positive impact. This poster explores a few of the primary and derived products that are being used to benefit restoration and research efforts, and to aid public and private decision-makers.

Maximizing Adaptive Capacity and Ecosystem Services: A GIS-based Approach to Managed Realignment

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Dykes and adjacent marshlands are of strategic importance for climate change adaptation as they provide the first line of defense for many coastal communities from storm surge, sea level rise and erosion hazards. Managed realignment within the Bay of Fundy region has been identified as a viable adaptation method to current and future risks associated with climate change. However, limited information exists about how to evaluate and prioritize appropriate sites. A GIS multi-criteria assessment framework was developed to provide a coarse prioritization of potential candidate sites for realignment in key estuaries within the region. A realignment score was calculated based on composite scores in the categories of ecosystem services (e.g., morphology, habitat quality, hydrology, biomass, connectivity) and adaptive capacity (e.g., accommodation space, dyke length, foreshore, width) less cost (e.g., infrastructure, dyke condition). A total of 64 cells, which were made up of 60 regulated marsh bodies, were classified into three classes of suitability. Seventeen percent of the marsh bodies analyzed were found to be unsuitable for realignment while forty two percent were found to be suitable. Forty-one percent were classified as proceed with caution. The framework developed offers advantages moving forward as the matrix format allows for the addition of new sites and the adjustment of weights and ranking scales in response to both new data and new questions.

An Analysis of Multispectral UAS for Salt Marsh Foreshore Land Cover Classification and DEM Generation

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Recent advances in Unmanned Aerial Systems (UAS), and increased affordability have proliferated their use in the scientific community. Despite these innovations, UAS attempts to map a site's true elevation are obstructed by vegetative canopies; resulting in the production of a Digital Surface Model (DSM), rather than the intended Digital Elevation Model (DEM). This project seeks to account for the varying heights of vegetation communities within the Masstown east saltmarsh, producing DEMs for mudflat/saltmarsh landscapes with an accuracy comparable to that the DSM. DEM generation has been completed in two separate stages. The first stage consists of land cover classifications using UAS derived, radiometrically corrected data. Respective land cover classifications are assessed using confusion matrices. Secondly, surveyed canopy heights and function derived heights are subtracted from their respective classes, generating the DEMs. DEM validation has been performed by comparing topographic survey point values to those modeled, using the Root Square Mean Error (RMSE) measure. The project then compares the various parameters implemented for land cover classifications, and DEM accuracy. DEM generation methods were then coupled to produce a final DEM with a RSME of 6 cm. The results suggest consumer grade Multispectral UAS can produce DEMs with accuracies comparable to the initial DSMs generated, and thus merit further studies investigating their scientific capacities.

Rehabilitating and Restoring Unique Landscapes within Five Nova Scotia Watersheds along the Bay of Fundy, Nova Scotia, Canada

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The watersheds of the inner Bay of Fundy are important both ecologically and culturally. They are critical habitat for the endangered inner Bay of Fundy (iBoF) Atlantic Salmon (*Salmo salar*) and were significant cultural and harvesting sites for our land's first inhabitants, the Mi'kmaq People. Unfortunately, the watersheds have become degraded over time due to anthropogenic activities, leaving watercourses inaccessible or unsuitable for fish.

Our five year study will investigate and address areas of fish habitat concern in the Chiganois, Debert, Folly, Great Village, and Portapique Watersheds. Through reconnaissance and surveys, planning, engineering, physical labour, and community support, we will help to restore fish habitat by enhancing coastal entry points and removing obstructions from migration routes for iBoF Atlantic Salmon and other migratory fish. Additionally, our study will collect local community knowledge and Aboriginal Traditional Knowledge about watercourses in each watershed to determine changes in the anthropogenic and fish use of the watercourses. This information will be used to set restoration goals and inform the restoration planning process. We will also assess and propose innovative solutions for

modification or replacement of the aboiteaux on the Chiganois River in collaboration with project partners and community members.

The outcomes from this project will be 1) increased knowledge of the five watersheds and their use by both fish and humans presently and in the past; 2) a scientifically supported management plan for each watershed that prioritizes fish habitat restoration actions; 3) increased capacity of local communities to protect, monitor, and restore fish habitat.

Biotic Communities and Environmental Conditions of Salt Pools for an Ongoing Salt Marsh Restoration in the Bay of Fundy, New Brunswick, Canada

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Salt marsh pools provide important habitat for wildlife (waterfowl, shorebirds and several species of fish) and thus are of interest in salt marsh restoration projects. Since 2010, one such marsh restoration project in Aulac, NB, in the upper Bay of Fundy (initiated by Ducks Unlimited Canada and partners) has been monitored annually to record the community succession of salt pool animals in minnow traps, invertebrate activity traps, and benthic grabs as well as changes in abiotic pool conditions (water salinity, pH, temperature, dissolved oxygen, flow). The project consists of two former farmland fields being restored to salt marsh after the breaching of agricultural dikes (restoration sites) and two adjacent established salt marshes used as reference sites (natural sites). The salt pools of the restoration sites remain different from the natural marsh pools as of 2017. They contain animal communities that more closely resemble mudflats or marsh creeks with annelid species, the amphipod *Corophium volutator.* as well as fewer fish. The abiotic conditions in the restoration sites' pools also show important differences, such as lower dissolved oxygen levels, and are more similar to conditions in the open bay than in the established salt pools in the natural sites. Measurements of water flow in the salt pools support this observation. Salt pool formation is poorly understood, and the results of this project indicate that it is a slow process. Future monitoring is necessary as development continues, especially because the recent dense growth of *Spartina alterniflora* around the pools may accelerate their stabilization and development.

Incorporating Climate Change Adaptation into the Aboiteau Upgrade Design for an Agricultural Marsh

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Aboiteaux, gated structures that provide a means of draining excess freshwater from agricultural land at low tide while preventing salt water infiltration at high tide, are crucial in ensuring minimal impacts of

flooding upstream. Due to increased precipitation caused by climate change and the fact that many aboiteaux were built in the 1950's, there is a need for several structures to be upgraded and/or replaced. Our project focused on examining a high-priority aboiteau located in Highland Village, Nova Scotia, owned and maintained by the Nova Scotia Department of Agriculture. We have developed a procedure for determining the required structure capacity by incorporating climate change projections as well as a means for assessing hydraulic performance based on a variety of design configurations. A final recommended design solution was determined through evaluating each alternative by several factors (e.g., cost, serviceability, performance). This project provides a framework that can be adapted to aid in aboiteau upgrade/design and the results accentuate the importance of understanding and assessing climate change impacts on these drainage structures and the agricultural land they protect.

Ribbed Mussels (*Geukensia demissa*): An Important Ecosystem Engineer Conspicuously Absent from Salt Marshes in the Bay of Fundy

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Ribbed mussels contribute to the productivity of salt marshes along the Atlantic coast of North America, from Florida to the Gulf of St. Lawrence. However, little is known about their population dynamics at their northern range limit, Maritime Canada. As a step in modelling ribbed mussel populations at their northern range limit, we quantified ribbed mussel density (# m^{-2}) and size (mm shell length) in 2 different microhabitat types (the exposed marsh edge and the marsh creeks) at 25 sites along the east coast of New Brunswick, 4 sites along the Bay of Fundy coast of New Brunswick, 11 sites along the Gulf Shore of Nova Scotia, and 10 sites along the coast of Maine. Ribbed mussels were not found in the Bay of Fundy, but were present along the southern coast of Maine (average ± SD: 1.8 ± 6.2 mussels m^{-2}). Density decreased to zero along the northern coast of Maine and in the Bay of Fundy, likely due to decreased temperatures, limiting larval development, and increased sediment loading, reducing filter feeding efficiency. Ribbed mussel densities were highest (120.7 ± 26.8 mussels m^{-2}) in the central Northumberland Strait, but varied substantially within and among sites and microhabitat types. Densities were close to zero between Bouctouche and Kouchibouguac National Park, likely due to low-amplitude and infrequent tides, increased along the Acadian Peninsula (8.9 ± 10.9 mussels m^{-2}), and decreased to zero in Chaleur Bay (northern New Brunswick), likely due to low salinities. This study provides the first demographic information for ribbed mussel populations in Maine and Maritime Canada and, as such, provides important baseline information to compare to potential future range shifts caused by climate change.

4.3 Fisheries Ecology and Coastal Management

Tracking the Development of Individual American Lobster Embryos to More Accurately Predict Time of Hatch

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Connectivity among American lobster populations influences stock structure and recruitment dynamics, knowledge of which is important to the management of lobster fisheries. Models of connectivity via larval drift are, however, sensitive to variation in the timing of embryo hatch. In this study we raised ovigerous female lobsters (n=12) and individual embryos detached from the female (n=24/female) at ambient (7–13°C) and constant (8°C ±0.5°C) temperature, from May to August 2017, to increase our understanding of embryo development rate and stage at hatch. We used two potential indices of embryo development, the Perkins Eye Index (PEI) and a Yolk Index (YI). Every second week until all larvae had hatched, we measured PEI and YI of 24 randomly selected embryos removed from each female and of all 288 individually raised (detached) embryos. We will: i) compare development rate and stage at hatch of attached versus detached embryos; ii) quantify how intra- and inter-brood variability in development rate and stage at hatch affect the hatch period; iii) determine whether the PEI or YI provides the better metric of embryonic development; and iv) determine the extent to which our prediction of hatch time is improved by randomly allocating to different embryos, through simulations, the variability in development rates and stage at hatch observed during our study. Results are expected to enhance our ability to monitor and predict embryo development, which is expected to help improve predictions of larval release time in nature and accuracy of modelled connectivity between lobster stocks.

Integrated Watershed Management: A Case Study in Collaborative Strategic Planning between Clean Annapolis River Project and the Municipality of the County of Annapolis

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The Annapolis River watershed is the third largest watershed in Nova Scotia, draining an area of 2250 km^2. Originating at Caribou Bog in the western Annapolis Valley, the Annapolis River flows downstream through portions of Kings, Annapolis and Digby Counties, into the Annapolis Basin, a sub-basin of the Bay of Fundy. Clean Annapolis River Project (CARP), a community based non-government organization, has been working in this area since 1990 to address ecological issues at a watershed scale.

Recognizing the importance of integrated watershed management, CARP has continually worked to develop strong working relationships with the various decision makers and stakeholders across the watershed. In 2017 CARP partnered with the Municipality of the County of Annapolis to undertake a consultative process with community members and stakeholders in the Annapolis River watershed, in order to guide the integration of community and stakeholder values, CARP's organizational strategy, and

the County of Annapolis' Economic Development Strategy 2050, toward ecological management actions that support cultural, social, economic, and environmental values.

By undertaking this process with support of the Municipality, CARP is better positioned to focus its efforts on the issues of greatest import and impact to the residents of the region while aligning and supporting the existing municipal initiatives, particularly the County's policy to "support and foster efforts to remediate, manage, and ensure clean air, water, and soil." Key community concerns served as the themes for subsequent stakeholder meetings and will be used to develop future collaborative projects among stakeholders.

Characterizing the Horse Mussel (*Modiolus modiolus*) Reef Population in the Bay of Fundy

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Horse mussels (*Modiolus modiolus*) have been known to exist in the Bay of Fundy (BoF) for a long time, but their current population structure is unknown. Horse mussels can provide important biogenic habitat and in 2012 Fisheries and Oceans Canada (DFO) designated an area of mussel reef in the BoF as an ecologically and biologically significant area (EBSA). The objective of this study was to characterize the current population structure of horse mussels in this EBSA. In the summer of 2017, physical samples were collected from 19 stations in areas identified as potential *Modiolus* reef with a modified scallop dredge lined with a 38 mm mesh. From each station, all live and dead (empty hinged shell) horse mussels were collected and returned to the Bedford Institute of Oceanography for processing. Population characteristics were obtained from mussels that were either live and intact, live with crushed shell, or dead. This included sex, viscera wet and dry weights, and valve lengths, heights, widths and weights. Live horse mussels were found in 13 of the 19 stations sampled. Results to date indicate that there are more females than males in the population (female to male ratio of 2.3:1), with the majority of both sexes between 90 and 150 mm in length, and few juveniles observed. This study provides important information on the current population status of horse mussels in the BoF which will aid DFO in determining future management of this area.

Using Temperature-Dependent Embryonic Growth Models to Predict Time of Hatch of American lobster, *Homarus americanus*, in Nature

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Hatch time affects the temperature experienced by developing American lobster (*Homarus americanus*) larvae, and hence the time and distance they will drift before settling. In principle this hatch time can be estimated over large geographic areas by working with fishermen and inspecting the brood of gravid

females caught in their traps. However, this requires frequent sampling, given the hatch period is protracted, and (more importantly) would often require dedicated and expensive sampling as hatch occurs "outside" of the fishing season over much of the species' range. To address these limitations, we tested the accuracy with which hatch time in nature can be predicted by (1) taking egg samples during the fishing season, (2) estimating embryo development using embryonic eye size and lab-derived temperature-dependent development functions, and (3) comparing predicted hatch dates to the period of hatch observed by sampling out-of-season alongside fishermen. Utilizing samples obtained prior to the beginning of hatch we were able to predict with surprising accuracy the period over which hatch occurred, including hatches up to ≈ 15 weeks in the future, as well as the progression of hatch over this period. Our results suggest that samples can be obtained in collaboration with fishermen to predict hatch time with sufficient accuracy to enhance our ability to predict spatial connectivity via dispersal of larvae, which will become increasingly important as climate change alters oceanographic conditions.

Expansion of the Bay of Fundy Western Hemisphere Shorebird Reserve Network Designation

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For the past 30 years, Shepody Bay and the Southern Bight of Minas Basin in the inner Bay of Fundy have been internationally recognized as important to shorebirds through the Western Hemisphere Shorebird Reserve Network (WHSRN) designation. Findings from recent research (2011–2016) conducted jointly by Mount Allison University and Environment and Climate Change Canada's Canadian Wildlife Service, and data from aerial survey counts (1976–2014) of Semipalmated Sandpipers, have identified intertidal mudflats and beaches where large groups of shorebirds congregate outside of the current WHSRN site. The Nature Conservancy of Canada (NCC) is working to have these areas recognized to help improve the conservation outcome of the world population of Semipalmated Sandpipers *(Caladris pusilla) and* Red Knot rufa subspecies *(Caladris canutus rufa).* In fall of 2018, NCC will apply to WHSRN Council seeking a nomination for the expansion of the current Bay of Fundy WHSRN site to include Cumberland Basin and Cobequid Bay in New Brunswick and Nova Scotia. If accepted, all four areas will be formally recognized as a WHSRN "Landscape of Hemispheric Importance".

5. Next Steps for BoFEP – Moving Ahead with a Focused Program[13]

As an NGO with modest funding and currently running with a very small steering committee, BoFEP should move ahead with a focus on a few activities and achievable goals, following from the insights and advice of this workshop panel and the participating audience, as well as from previous recent discussions at retreats and annual meetings with its current steering committee members. There has been no shortage of ideas!

A number of core activities are required to sustain the environmental health of the Bay of Fundy, in the age of climate change and demand for living resources and energy (Figure 1). It is suggested that BoFEP members work actively in three areas – networking (with groups with Fundy interests), information synthesis and communication, and education (ocean literacy and awareness) – and contribute with its partners to other programs – longer-term planning for the health (and environmental sustainability) of the Bay of Fundy, policy and decision-making related to ICM for the Bay, and continued scientific research and monitoring on all aspects of the Bay's ecosystem, living resources and surrounding watersheds.

Figure 1. Proposed Areas of Focus for BoFEP – 2018 onwards

Core Work	
Networking	In order to envisage and build on a common vision for a sustainable future for the Bay of Fundy, this activity would include linking to a number of environmental and resource organizations, government departments and community groups concerned about the health and future of the bay and involved in identifying key issues of concern. BoFEP could "stitch this network together, maintain the relationships formed at the workshop, and be the (or one of the) coordinating body". It could also involve identifying specific projects that could be jointly funded. The revised and active website, along with Facebook and other forms of social media, will be critical to this task and central to all of BoFEP's activities.
Information Synthesis and Communication	BoFEP should continue in its role related to communication on Fundy issues, using its website, its Fundy newsletter, and its biennial and topic-specific workshops. Periodically, a key fact sheet should be produced or updated, such as one on Emerging Issues or Climate Change. As well, BoFEP should complete the book on Fundy Issues (a project started several years ago with DFO funding and very near completion). The basics about the Bay of Fundy should be available in a document with accessible language – perhaps a relevant chapter should be written for the Fundy book. The tourism departments in

[13] Drafted by Wells, based on the panel notes and reflection on what seems to be achievable by BoFEP in its next phase. This is for discussion at the Fall 2018 Steering Committee meeting, after which a work program can be detailed, provided members of Steering Committee and others to take on specific tasks.

	both provinces should be involved (as it was many years ago when we had a WG on this topic).
Education (Ocean Literacy and Awareness)	BoFEP now has a working group on this topic - see Mike Butler's summary document from the workshop. Information packages, summer camps and training workshops should be considered. Linkage to other like-minded groups should be considered, such as the GOMI's course (G. Daborn's suggestion). Is there a simple way to compile a listing of volunteer speakers that we could circulate to the schools? See Mike's document for more insights about this crucial initiative.
Further Collaborative Work with Partners	
Long-term Planning for the Bay	A vision for the Bay of Fundy is needed, one stretching out 20-30 years at least. BoFEP should contribute to the ICM (integrated coastal management plan and program) apparently being developed for the bay by DFO and its partners. Active participation in the upcoming Gulf of Maine (GOM) workshop (March 2019) and symposium (Nov. 2019), with the focus on climate change and its implications for the GOM region, is critical to this activity.
Policy and Decision-making Related to Integrated Coastal Management	BoFEP has a working group on this topic, i.e., the EIUI research program at Dalhousie University (www.eiui.ca) that evolved out of the Informatics WG. Its area of focus is understanding the science-information-policy interface(s) in ICM (or ICOM) and a number of projects have been Fundy or GOM related, with various government and NGO partners. A panel was held on this topic at the workshop. Are there other initiatives that BoFEP could undertake on this topic?
Scientific Research and Monitoring	BoFEP's primary contribution has been two fold – 1) supporting local research by conducting the biennial workshops, and periodic special workshops on Fundy research, with many partners and sponsors, and 2) running contract projects on specific topics of concern and interest, e.g., the recent Living Shorelines project. A large body of information from these efforts has been produced over the past 20 years – see www.bofep.org/publications . BoFEP's main role should be to stimulate continued discussion about research priorities, and to participate in key meetings and conferences that lead to new research on key problems. Participation in the upcoming GOM workshop and conference is very important in this context, given the overriding importance of climate change to the whole GOM region.

The success of this new program of work rests upon the resources, energy and commitment of members of the BoFEP team – the Management and Steering Committees, the Communications coordinator and webmaster, and the members of BoFEP (the broad membership, including the workshop participants) – as well as the availability of base funding from members and partners. How BoFEP addresses these challenges will be discussed at the Fall 2018 Steering Committee meeting.

6. Workshop Field Trip – Tidal Bore Rafting

A Fundy field trip was organized for Saturday, May 12th, tidal bore rafting on the nearby Shubenacadie River estuary. Alas, only two of the workshop participants went on this trip – Joshua McNeely and Peter Wells – both members of the organizing committee – but we had great fun and a unique experience of paying to get wet and frozen and bounced around for a couple of exciting, breathtaking hours. The trip was with Fundy Tidal Bore Adventures, near Brooklyn, and located right on the estuary. We met there at 0900 hr, and with six other people, local tourists, we dressed in watertight outer clothing (actually not so watertight!) and walked across some mudflats to a large zodiac. We clambered aboard and motored up the estuary to a prime place to meet the incoming tidal bore. And when the bore came upriver, it really came, the water swirling into major rapids very quickly which we then took turns to run. It was quite exciting! The water came straight over the bouncing boat and soaked everyone constantly. After a couple hours or so of this, we motored slowing downstream and enjoyed seeing dozens of bald eagles in the air, of various ages, circling above us. Apparently this part of Nova Scotia has the highest density of nesting eagles in the province. Despite the chill, the birds made the trip extra special and we arrived back at base, happy with the experience. A good field trip and unique Fundy experience. (Written by Peter Wells)

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The 13th BoFEP Bay of Fundy Science Workshop

"Fundy's Future in an Era of Climate Change"

Date: 2020

Location: To be determined in New Brunswick

Proposed Major Topics:

Climate change and the Gulf of Maine/Bay of Fundy
Tidal power development
Oceanography of the Bay
Mass mortality events
The future of wild fisheries
Marine protected areas
Recovery of the Petitcodiac estuary
Shoreline issues
Conservation of migratory shorebirds
Plastics and chemical contaminants
Coastal communities – Issues of concern
Invasive species
Ocean literacy and communications
Impact of run-off on the Bay of Fundy

Other topics for sessions are welcomed and encouraged

For up-to-date information

Visit the BoFEP Web site: www.bofep.org